UNIVERSIDADE DE LISBOA
FACULDADE DE CIÊNCIAS
DEPARTAMENTO DE BIOLOGIA ANIMAL

Effects of seasonality on the responses of Neotropical bats to local- and landscape-scale attributes in a fragmented landscape

Mestrado em Biologia da Conservação

Diogo Filipe Angelo Ferreira

Dissertação orientada por:
Dr. Christoph Friedrich Johannes Meyer
José Ricardo Teixeira Rocha

2015

Agradecimentos

Esta investigação foi financiada pela Fundação para a Ciência e a Tecnologia (FCT) através do projeto "Temporal dynamics of the impacts of forest fragmentation on Neotropical bat assemblages".

Ao Christoph Meyer, por ter ser sido um orientador espetacular e ter estado lá sempre que eu tinha alguma dúvida ou problema. E a cima de tudo por ter confiado em mim e ter-me dado a oportunidade de ir à Amazónia.

Ao Ricardo Rocha, por me ter ajudado não só na elaboração desta tese mas por ter feito um papel magnífico enquanto meu orientador. Mas acima de tudo por ter sido um grande companheiro de campo e de trabalho, e ter tornado a estadia na Amazónia ainda mais magnífica.

Ao Adrià López-Baucells, por todo o apoio e ajuda que me deu ao longo deste ano, que foi muito mais do que eu alguma vez esperaria. E como é lógico, por todos os momentos e discussões que tornaram as recordações da Amazónia ainda mais espetaculares.

Ao pessoal, por me ajudarem a superar todas as frustrações que ocorreram ao longo desta etapa e estarem lá sempre presentes para ir beber uma jola. Vocês são awesome. Em especial à Marta Nabais, que para além de ter estado lá sempre, foi uma ajuda enorme na redação desta tese e um exemplo ao longo destes anos.

Aos meus pais, porque sem eles nada disto seria possível e não sei o que seria de mim sem a ajuda deles. Espero que todos os sacríficos que fizeram tenham valido a pena, e independentemente do que conseguir na minha vida, estarei sempre grato e serão sempre o meu maior exemplo de vida.

"If I have seen further, it is by standing on the shoulders of giants"

Isaac Newton

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Resumo

Nos trópicos, o acréscimo da desflorestação está a originar paisagens compostas por fragmentos de pequenas dimensões de floresta natural (floresta primária) circundada por uma matriz de habitat modificado. A sazonalidade nos trópicos é marcada por diferenças na precipitação, sendo que estas diferenças entre a estação seca e húmida podem levar a alterações na produtividade primária, no crescimento e nos padrões de frutificação e floração de algumas plantas tropicais. Estas mudanças na produção primária podem provocar oscilações na disponibilidade de recursos, afetando a presença e a abundância não apenas de espécies frugívoras e nectarívoras, mas também de espécies insectívoras. Quando a sazonalidade atua conjuntamente com a fragmentação, os impactos da última sobre a biodiversidade podem ser agravados. Isto acontece porque as flutuações naturais na disponibilidade de recursos podem ser alteradas tanto por diferenças nas condições microclimáticas nas bordas dos fragmentos como pela matriz de habitat modificada ação humana. Adicionalmente, a fragmentação pode ainda impedir migrações sazonais e diminuir o acesso a recursos essenciais, impedindo o acesso a recursos (alimento e abrigo) necessários durante e.g. as épocas de reprodução. Os morcegos são considerados um grupo de grande interesse para o estudo dos impactos da fragmentação nos Neotrópicos, este facto deve-se à sua grande abundância, riqueza específica, diversidade ecológica, mobilidade e importância como bioindicadores. O voo dota os morcegos de uma maior capacidade de deslocação em paisagens fragmentadas do que outros grupos faunísticos menos móveis. No entanto, devido a diferenças nas características biológicas e ecológicas entre espécies, as respostas a estas perturbações são muito variáveis. Estas diferenças interespecíficas, i.e. nos hábitos alimentares, são afetadas pela sazonalidade, influenciando a forma como diferentes espécies respondem às características de composição e configuração da paisagem e à estrutura da vegetação ao nível local. Apesar de muitos estudos já terem averiguado os impactos da fragmentação ao nível da população e da comunidade nos Neotrópicos, poucos foram realizados ao longo de grandes períodos, e consequentemente as variações sazonais nas respostas dos morcegos foram raramente consideradas.

Neste estudo avaliámos como diferentes espécies de morcegos respondem à sazonalidade numa paisagem caracterizada por fragmentos de diferentes tamanhos e circundados por uma matriz de floresta secundária em diferentes estágios sucessionais. Recorrendo a dados de dois anos de capturas, averiguámos como é que padrões gerais da abundância de diferentes espécies de morcegos variam entre a estação seca e húmida nos fragmentos, na matriz de floresta secundária e em áreas de floresta contínua. Para além disto, analisámos a influência da estrutura da vegetação (métrica de escala local), e das métricas da composição e configuração da paisagem (para cinco escalas espaciais) na abundância de oito espécies de morcegos. Testámos também se a importância das métricas variava entre as estações.

O estudo foi realizado no Projeto Dinâmica Biológica de Fragmentos Florestais (PDBFF), Amazónia Central, Brasil. Os morcegos foram capturados durante dois anos em oito fragmentos e nove áreas de controlo. Em cada categoria de habitat foram amostrado o interior, a borda e a matriz. As métricas da paisagem foram obtidas para a

área do PDBFF, tendo sido utilizados *buffers* de cinco tamanhos diferentes (250, 500, 750, 1000, 1500m de raio) em cada um dos 39 locais de amostragem. Para cada uma dos *buffers* foram calculadas quatro métricas de composição: cobertura da floresta primária, coberturas da floresta secundária – estágio inicial (6 < idade) estágio intermédio (6 ≥ idade < 16) e estágio avançado (idade ≥ 16). Adicionalmente, foram calculadas também quatro métricas de configuração: densidade de bordas, densidade de fragmentos, distancia ao vizinho mais próximo e índice médio de forma. Modelos lineares generalizados mistos foram usados para testar as diferenças na abundância de cada espécie entre as estações (seca e húmida) e entre os tipos de habitat (interior, borda e matriz). Por último, para determinar a importância de cada métrica em cada estação usámos uma Partição Hierárquica.

Os padrões da abundância variaram com a espécie e o tipo de habitat, e foram observadas diferenças entre as estações em todos os tipos de habitat. As relações entre a abundância das espécies com a estrutura da vegetação local e com as métricas da paisagem foram dependentes da estação e da escala. As métricas da composição foram, no geral, mais influentes na estação seca, enquanto a estrutura da vegetação local e as métricas da configuração foram por sua vez mais influentes na estação húmida. A maneira como as diferentes espécies responderam a estas métricas variou entre as espécies frugívoras e as espécies animalívoras. Na estação seca, os morcegos frugívoros responderam mais às métricas da composição enquanto na estação húmida a escala local e as métricas da configuração foram mais marcantes. Os morcegos animalívoros demonstraram padrões similares entre as duas estações, respondendo ao mesmo grupo de métricas na estação seca e húmida. Devido a resultados bastante específicos para cada escala e para cada espécie, padrões gerais em relação às métricas mais importantes em cada escala espacial foram difíceis de identificar. No entanto, as métricas de composição e configuração foram selecionas em todas as escalas espaciais para as duas *ensembles* sem padrões discerníveis, mas a estrutura da vegetação mostrou padrões mais consistentes entre as escalas espaciais para as espécies frugívoras. No geral, a floresta secundária estava associada positivamente com a abundância dos frugívoros enquanto para as espécies animalívoras esta estava associada negativamente, sendo que este padrão se destacou sobretudo na floresta secundária de estágio sucessional avançado.

As taxas de captura variaram entre as estações, sendo que algumas espécies demonstraram padrões sazonais evidentes. Estas diferenças de abundância ocorreram sobretudo nos habitats modificados (fragmentos, bordas e matriz), e estão provavelmente relacionadas com diferenças fenológicas nos períodos de floração e frutificação na matriz de floresta secundária. A associação positiva com a floresta secundária e a variabilidade nas respostas à fragmentação dos morcegos frugívoros parece suportar esta hipótese. Os morcegos animalivorous demonstraram padrões similares entre a estação seca e húmida, indicando que para esta *ensemble*, a sazonalidade e consequentemente a variabilidade na disponibilidade dos recursos pode não ser tão importante quanto para os morcegos frugívoros.

É ainda importante desenvolver estudos de forma a poder perceber como cada espécie explora o habitat e como a respetiva dieta é afetada pela fragmentação e pela sazonalidade, especialmente quando efeitos sinergéticos entre a fragmentação e sazonalidade podem desencadear efeitos ao nível das interações planta-morcego, diretamente através da dispersão de sementes e polinização e indiretamente através do controlo de artrópodes herbívoros. Em paisagens fragmentadas, os morcegos beneficiarão de ações que visem promover a regeneração da floresta secundária, de forma a minimizar o contraste entre fragmentos e a matriz. No entanto, a preservação das florestas primárias e contínuas deve ser priorizada, de modo a garantir condições de habitat adequadas não só para as espécies frugívoras mas também para as espécies animalívoras. Por último, a sazonalidade deve também ser consideradas nas ações de conservação para garantir que os morcegos possuam os recursos necessários durante a época não reprodutiva e reprodutiva, sendo a segunda, a época que exige uma maior necessidade de recursos alimentares por parte deste grupo taxonómico.

Palavras-chave: morcegos, fragmentação, sazonalidade, estrutura da paisagem, estrutura da vegetação local.

Abstract

Changes in plant production can cause oscillations in resource availability, affecting the presence and abundance not only of frugivorous and nectarivorous bats, but of insectivorous bats. When seasonality is associate with fragmentation, it can exacerbate the impacts of the latter. We evaluate how different bat species respond to seasonality in a fragmented landscape characterized by different-sized fragments of primary forest surrounded by a matrix comprised of secondary forest in different successional stages. Based on two years of capture data, we assessed how general patterns of different bat species abundance changed between the wet and dry seasons in forest fragments, secondary forest sites, and continuous forest controls. Measurements of landscape characteristics were obtained for BDFFP landscape and posteriorly general linear mixed-effects models to examine the relative effects of local vegetation characteristics and landscape-scale metrics in shaping bat abundance patterns. Relationships between species abundances and local vegetation structure and landscape characteristics were both season-specific and scale-dependent. The way that species responded to these metrics varied between frugivorous and animalivorous species. In the dry season, frugivores responded more to compositional metrics whereas during the wet season local and configurational metrics were more important. Animalivorous species showed similar patterns in both seasons, responding to the same group metrics in the wet and dry season. These suggest that for animalivores, seasonality and consequently the variability in resource availability may not play such an important role as it does for frugivores. Differences in responses occurred probably due the differences in the chronology of flowering and fruiting events between primary forests and secondary forest matrix, which affected the dietary habitats of bats in fragmented landscape. Management actions should promote the secondary forest regrowth and consequently minimize the fragment and matrix contrast in order to maintain and improve habitat quality for bats, although measures should prioritize primary forests conservation to preserve both frugivores and animalivores. Finally, seasonality should be considered in management actions to guarantee that bats have the necessary resources during non-breeding and breeding seasons.

Key-words: bats, fragmentation, seasonality, landscape structure, local vegetation structure.

Introduction

Tropical forests are the most diverse biome on the planet, harbouring more than 60% of all known plant and animal species (Bradshaw et al. 2008). This is even though they only represent about 7% of the Earth's terrestrial surface (Bradshaw et al. 2008). Despite the significant importance of these ecosystems, they have been subjected to strong anthropogenic pressures in the past decades, threatening the long-term stability of tropical forest biota (Bradshaw et al. 2008; Laurance et al. 2014). The rapid loss of primary forests and the consequent habitat fragmentation are among the greatest threats to topical biodiversity (Gibson et al. 2011; Laurance et al. 2011).

In the Amazon, increasing deforestation for cattle ranching, agriculture and logging (Asner et al. 2005; Fearnside 2001; Laurance et al. 2011; Laurance et al. 2014), is leading to the formation of landscapes composed by small fragments of natural forest surrounded by a matrix of modified habitat (Laurance et al. 2011). Numerous studies over the last years have shown the strong and negative impacts of forest fragmentation on animal populations in the Amazon basin (e.g. Benchimol & Peres 2015; Figueira et al. 2015; Laurance et al. 2011) and elsewhere across the tropics (e.g. Benchimol & Peres 2013; Bregman et al. 2014; Ewers & Didham 2006; Meyer et al. *in press*). The negative impacts of fragmentation are not only associated with the consequences of deforestation *per se*, but also, directly or indirectly, with a series of other disturbances. The isolation of wildlife populations due to a decrease in connectivity between patches of suitable habitat (Quesada et al. 2004; Struebig et al. 2008) can cause the disruption of natural movement and gene flow (Laurance et al. 2004). Generalist or exotic species that are better adapted to fragmentation and disturbance (Goosem 1997) can occupy the niches of more specialized species, replacing them across the landscape. Fragmentation can also cause alterations in abiotic conditions (e.g. strong winds and higher temperatures) at the border of fragments (Ewers & Banks-Leite 2013; Laurance et al. 2002), causing edge effects (e.g. lower relative humidity and tree mortality) that can extend up to 2 km into continuous forest (Watson et al. 2004). In addition, the increase in accessibility to humans can lead to increases in hunting and exploitation of tropical fauna, exacerbating the consequences of fragmentation (Dirzo et al. 2014; Peres 2001). These factors combined lead to tropical forest remnants that only contain a small portion of the original biodiversity and communities that often differ markedly in terms of species abundance, richness and evenness from those of areas of continuous forests (Ewers & Didham 2006; Ferraz et al. 2003).

Throughout the tropics, high rates of deforestation have drastically increased the number of old-growth tropical forest (primary forest) patches surrounded by an anthropogenically modified matrix, such as second-growth forests, agricultural fields, plantation forests and pastures (Melo et al. 2013). These modified matrices can act as a hostile environment and as a selective filter, influencing the connectivity between remnant forest patches (Gascon et al. 1999). However, it has been shown that anthropogenically modified landscapes are not completely inhospitable habitats and depending on the type of matrix and on the ecological traits of species, they can be crucial for the survival of numerous animal species (Cisneros et al. 2015; Kupfer et al. 2006; Mendenhall et al. 2014; Watson et

al. 2004). Globally, tropical secondary forests represent one-sixth of all primary forest that was cut during the 1990s (Wright 2005) and an estimated 20% of all the deforested area in the Brazilian Amazon has regenerated to some type of secondary forest (SF) (Bentos et al. 2013). The structural similarities between SF and primary forest (Ferreira & Prance 1999), which determine the importance of SF in terms of resources for foraging, nesting and protection for an array of animal taxa, makes it important to take into account how SF affect the community dynamics in fragmented landscapes. The structure and composition of SF is dependent on its age, i.e. successional stage. In terms of floristic composition a SF will only resemble old-growth forests after decades or even centuries (Guariguata & Ostertag 2001), and plant species turnover will be different depending on land-use history (Bentos et al. 2013). Therefore, it is necessary to not only analyse species responses to SF as a whole, but also to assess how they vary according to its structural and compositional characteristics, successional stage, and landscape context.

Bats (Chiroptera) are the second most diverse group of mammals with over 1300 recognized species (Fenton & Simmons 2015), only exceeded by rodents (Kalko 1998). They reach their highest richness in the Neotropics (Kalko 1998; Patterson et al. 2003), where they are known to provide key ecosystem services (Kunz et al. 2011). The Phyllostomidae is one of the richest and most diverse mammalian families in this region, of broad dietary scope that ranges from fruits, pollen, leaves, insects and small vertebrates, to blood (Kalko 1998). Through seed dispersal, pollination, regulation of small vertebrate and invertebrate populations and translocation of nutrients and energy bats play an important role in the maintenance of tropical ecosystems (Kunz et al. 2011; Lobova et al. 2009; Maas et al. 2015). Their high abundance, taxonomic diversity and community complexity associated with their sensitivity to a variety of environmental change impacts (García-Morales et al. 2013; Rebelo et al. 2010), makes them highly relevant as indicators of ecosystem changes (Barlow et al. 2015; Jones et al. 2009).

Globally, many populations of bats are affected by the high rates of deforestation and habitat degradation (Meyer et al. *in press*), factors that contribute to almost 25% of all bat species being considered threatened (Schipper et al. 2008). Due to their high abundance, richness, ecological diversity, mobility and their importance as bioindicators bats are considered an ideal indicator group to study the impacts of fragmentation in the Neotropics (Klingbeil & Willig 2010; Meyer & Kalko 2008a). With the potential to move over large fragmented landscapes, bats could overcome the ecological barriers imposed by fragmentation (Faria 2006). However, due to differences in species-specific biological traits (physiological requirements, morphological adaptations and life histories) and ecological traits (environmental preferences and associated behaviours) responses to habitat disturbances are very variable (Meyer & Kalko 2008a). García-García et al. (2014) showed that bat species with a small home range or that rely on a specific habitat for foraging (e.g. primary forests) show limited movements in fragmented landscapes and that more generalist species are tolerant to disturbance and benefit from habitat fragmentation. Over the years several studies have documented the variability of these responses of Neotropical bats (reviewed in Meyer et al. *in press*), showing the importance of understanding how fragmentation affects bat populations, ensembles, and assemblages.

In the tropics, seasonality is marked not by a difference in temperature but by a difference in precipitation (MacArthur 1972). Differences in precipitation between the wet and dry season can affect primary productivity, growth, as well as leafing and flowering patterns of many tropical plant species (Bentos et al. 2008; Haugaasen & Peres 2005). Changes in plant production can cause oscillations in resource availability, affecting the presence and abundance not only of frugivorous and nectarivorous species (Castro & Espinosa 2015; Pereira et al. 2010), but also of insectivorous species (Beja et al. 2010; Hamer et al. 2005). In fragmented landscapes, natural fluctuations in resource availability can be altered as a result of different microclimatic conditions at forest edges (Ewers & Banks-Leite 2013; Laurance et al. 2002) and the surrounding human-modified matrix (Chazdon et al. 2009), leading to seasonal shifts in diet composition of animal species. Furthermore, fragmentation can disrupt seasonal movements and hinder the access to key resources (Kattan et al. 1994). Seasonality can therefore change the way animals use the habitat in fragmented landscapes. For instance, during seasons of low food availability more bird species use also small fragments in order to expand their foraging areas or use them as stepping stones to disperse to areas of higher food availability (Maldonado-Coelho & Marini 2004). Hence, seasonality can exacerbate the impacts of fragmentation, especially for species that are not able to overcome the ecological barriers of the matrix to exploit available resources in other areas.

Neotropical bats comprise different guilds and their activity patterns and reproductive cycles are influenced by seasonality (Bobrowiec et al. 2014; Durant et al. 2013; Ortêncio-Filho et al. 2014). The responses of bats to seasonality in fragmented landscapes are poorly understood (Cisneros et al. 2015; Klingbeil & Willig 2010), but it is known that the composition of local bat assemblages varies between seasons and years (Mello 2009). Cisneros et al (2015) studied the effects of seasonality on phyllostomid bat metacommunity structure in humanized landscapes of the Caribbean lowlands of Costa Rica. Klingbeil and Willig (2010), currently the only study addressing the effects of season on the responses of Amazonian bats to landscape structure, focused on population-, ensemble- and community-level responses. The authors demonstrated divergent responses of phyllostomid bats to landscape structure between seasons, whereby some species responded to landscape composition (e.g. forest cover and matrix type) in one season and to landscape configuration (e.g. edge density and patch density) in the other season. Although many studies across the Neotropics have assessed the impacts of fragmentation on bats at the population- and assemblage level (Meyer et al. *in press*), few were conducted over longer periods and consequently seasonal variations in species responses were rarely considered. Multi-seasonal studies are needed in order to understand how bat populations respond to seasonal variations in resource abundance and availability across fragmented landscapes characterized by differences in configuration and composition.

Many studies have shown that fragmentation responses at the assemblage level are often hard to detect, but that there are often marked responses at the population level (Meyer et al. *in press*). Responses at the population level are highly species- and ensemble-specific (Klingbeil & Willig 2009), highlighting the need for studies to focus on

the level of individual species. Seasonality plays an important role regarding the diversity and availability of food resources, not only in natural but also in fragmented landscapes (Cisneros et al. 2015; Klingbeil & Willig 2010), yet only Klingbeil and Willig (2010) investigated how bat populations respond to seasonal resource fluctuations in a fragmented landscape. Although local vegetation structure can be a better predictor of the activity of forest-dwelling bats than landscape-level attributes (Erickson & West 2003), neither Cisneros et al. (2015) nor Klingbeil & Willig (2010) jointly considered local- and landscape-scale variables in their analyses. Responses to fragmentation at the landscape-level are likely modulated by local-scale vegetation structure and influenced by season-specific variation in biotic and abiotic conditions, highlighting the importance of such integrated approaches to studying fragmentation effects.

In this study, we evaluated population-level responses of bats to seasonality in a fragmented landscape characterized by different-sized fragments of primary forest surrounded by a matrix comprised of secondary forest in different successional stages. Based on two years of capture data, we assessed how general patterns of bat abundance changed between the wet and dry seasons in forest fragments, secondary forest sites, and continuous forest controls. In addition, we analysed the influence of vegetation structure (local-scale variable) and, for five spatial scales, metrics of landscape composition and configuration on the abundance of eight bat species and tested whether the relative importance of local, compositional or configurational characteristics changed between dry and wet seasons. Due to the mobility of bats we anticipated that responses would be dependent on the local vegetation structure, especially when food resources are higher, and on the landscape struture. As per Klingbeil and Willig (2010) we expected bat responses to landscape structure to be season- and species-specific, and that different ensembles (animalivores and frugivores) would respond differently to seasonality. Specifically, we anticipated that frugivorous species would respond more to compositional metrics in the dry season and to configurational metrics in the wet season, and that animalivorous species would exhibit the opposite pattern. These patterns would reflect the availability and distribution of food resources across the landscape and the differential ability of species to exploit the resources in the secondary forest matrix. Finally, we predicted that abundances of frugivores in secondary forest would be higher than those of animalivores, and that abundances in advanced secondary regrowth forest would be similar to those in primary forest, due to the increase in similarity in vegetation structure and composition between them.

Methods

Study Area

This study was carried out at the Biological Dynamics of Forest Fragments Project (BDFFP). The BDFFP is the longest-running experimental study of forest fragmentation (Laurance et al. 2011; Lovejoy et al. 1986). The study area, encompassing 1000 km^2 (2°25´S-59°50'W) (Lovejoy & Bierregaard 1990), is located about 80km north of Manaus, Central Amazon, Brazil. The region is characterized by upland forest (*Terra firme)*, an unflooded Amazonian rainforest with nutrient-poor sandy soils or clay-rich ferrasols (Brown Jr & Prance 1987; Laurance et al. 2002). Elevation ranges from 50 to 100m (Lovejoy et al. 1986). The forest canopy often exceeds 30-37m in height, with emergent trees reaching 55m (Gascon et al. 1999; Laurance et al. 2002). The area is characterized by a very high tree diversity that may exceed 280 species per ha and by a relatively open understory dominated by stemless palms (Gascon et al. 1999; Laurance et al. 2004; Laurance et al. 2002; Mesquita et al. 2001). The climate of the region is classified as Am in the system of Köppen (Mesquita et al. 2001), with a mean temperature of 26.7ºC (Haugaasen & Peres 2005). There are two well-defined seasons: a dry season from July to November when precipitation occasionally drops below 100 mm/month and a wet season from November to June when precipitation can exceed 300 mm/month (INPA 2014; Laurance et al. 2011). Flowering and fruiting peaks occur in the dry season and in the beginning of the wet season, respectively (Haugaasen & Peres 2005).

Between 1980 and 1984, eleven fragments were experimentally isolated in undisturbed continuous forest: five 1-ha fragments, four 10-ha fragments and two 100-ha fragments. The fragments were initially surrounded by a matrix of cattle pasture. However, due to the ceasing of land use, a matrix of secondary forest has been developing since then. The matrix now consists of secondary forest in different successional stages (Carreiras et al. 2014), dominated by *Vismia* spp., in areas that were cleared and burned, and by *Cecropia* spp, in areas that were cleared without fire (Mesquita et al. 2001). The latter represents the natural regeneration path of the region (Williamson et al. 2012). The fragments have been re-isolated over time during various occasions, prior to this study most recently between 1999 and 2001 (Laurance et al. 2011), in order to maintain isolation.

Experimental design

The bat fauna was sampled at seventeen sampling sites: eight primary forest fragments – three of 1ha, three of 10ha and two of 100ha (Dimona, Porto Alegre and Colosso reserves) - and nine control sites spread over three areas of continuous primary forest (Cabo Frio, Florestal and Km-41 reserves) (Figure 1). Each fragment was sampled in the interior, edge and adjacent matrix (Figure 2). Interior sites were located on average 245 ± 208 m (mean ± SD) away from the fragment edge. Adjacent matrix sites were sampled 100m from each fragment border. In the control plots, a similar experimental design was used (Figure 2), with nine interior sites (three in each reserve), three edge sites

and three adjacent matrix sites. Distances between interior and edge sites in continuous forest were 1118 ± 488 (mean ± SD). Hence, a total of 39 sites were sampled (17 interior sites, 11 edge sites and 11 matrix sites).

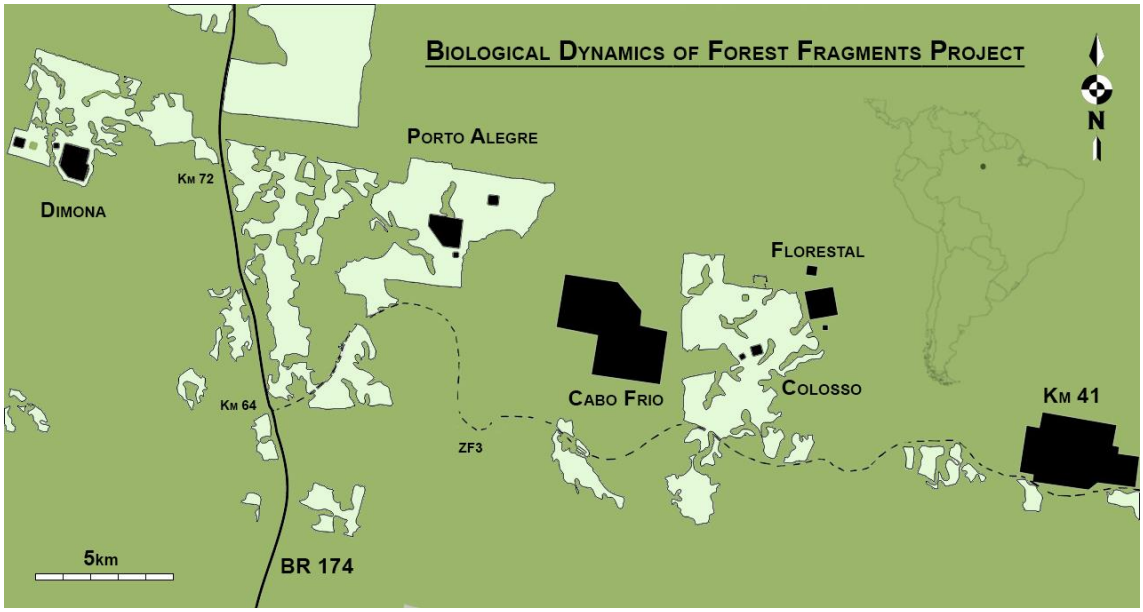


Figure 1. Map of the Biological Dynamics of Forest Fragments Project (BDFFP) study area in the central Amazon. Black areas represent the fragments and areas of continuous forest. Light green areas represent the surrounding matrix, i.e. the secondary forest, and dark green the continuous forest, i.e. the primary forest. See Figure S1 for the distribution of the different successional stages of secondary forest.

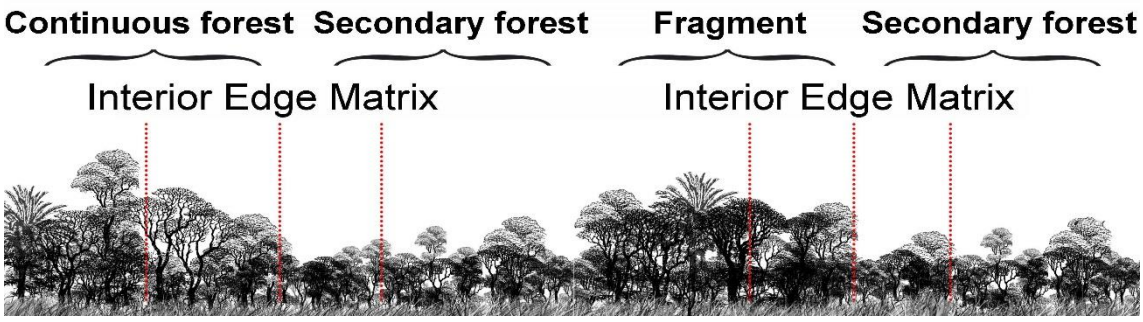


Figure 2. Schematic representation of the sampling design.

Bat sampling

Bats were captured using ground-level mist nets during the dry season (July to November) of 2011 and 2012, and the wet season (February to June) of 2012 and 2013. Each interior site was surveyed eight times, four times in each season. The number of visits to border and matrix sites ranged from 3-6 in the wet season and 2-3 in the dry season. For each survey, 14 mist-nets (12 x 2.5 m, 16 mm mesh) were used in continuous forest and fragment interiors, and seven mist-nets at the edge and adjacent matrix sites. Nets were left open during 6 h from dusk to midnight and were revised at intervals of ~20 min. The same site was never surveyed during two consecutive nights, to avoid net-shyness related capture bias (Marques et al. 2013). Adult bats (excluding pregnant females) were marked with numbered ball-chain necklaces (*Pteronotus parnellii* and frugivores) or transponders (gleaning animalivores) in order to quantify the rate of recaptures. Species identification followed Lim and Engstrom (2001) and Charles-Dominique et al. (2001), and taxonomy follows Gardner (2008). The analyses were limited to phyllostomids and *Pteronotus parnellii*, due to under-representation of other families and species with this type of sampling method (Kalko 1998).

Environmental characteristics

Local-scale variables

For each of the 39 sites we quantified vegetation characteristics within three $100m^2$ (5 x 20m) plots established 5 m from each side of the mist net transects (see Farneda et al. 2015). Within each plot, we measured the diameter at breast height (DBH) of all trees with DBH ≥10cm, determined the number of woody stems (DBH <10cm), trees (DBH ≥10cm), palms, lianas and pioneer trees, and estimated the canopy cover (%) based on the average of four spherical densiometer readings. The height of the five closest trees and the vertical foliage density (VFD) were visually estimated. VFD was calculated as the sum of the values obtained by the estimation at seven height intervals (0-1m, 1-2m, 2-4m, 4-8m, 8-16m, 16-24m, 24-32m) using 6 categorical classes (0 = no foliage, 1 = very sparse 0-20%, 2 = sparse 20-40%, 3 = medium 40-60%, 4 = dense 60-80%, 5 = very dense 80-100%). At each sampling site, values were calculated as the average across replicated plots (Table S1).

All vegetation variables were log(x + 1) transformed to reduce skewness. To reduce the dimensionality of the data, we performed a Principal Components Analysis (PCA). Prior to the analysis, a z-score standardization was done, i.e. variables were standardized to a mean of zero and a standard deviation of one. The first axis represented 42.02% of the total variance and was positively associated with DBH, canopy height, canopy cover, number of palms and trees, and VFD and negatively associated with number of woody stems, lianas, and *Vismia* and *Cecropia* trees (Table S2). The scores of the first axis (PCA 1) were used as predictor variable summarizing vegetation structure (Figure S2).

Landscape structure

Measurements of landscape characteristics were obtained from a detailed digital map of the BDFFP landscape based on 2011 Landsat Thematic Mapper. The map was classified into four land cover types, representing continuous primary forest as well as the different successional stages of the secondary forest matrix (initial: ≤5 years, intermediate: 6-15 years, advanced: ≥16 years) (see Carreiras et al. 2014) (Figure S1). To assess scale-dependency in bat responses to fragmentation, we used buffers of five different sizes (250, 500, 750, 1000, 1500m radii) centred on each of the 39 sampling sites. These focal scales were selected in order to encompass the expected home ranges of different-size bat species (Meyer & Kalko 2008b). As done elsewhere (Cisneros et al. 2014; Cisneros et al. 2015; Klingbeil & Willig 2009, 2010), landscape structure was characterized by compositional and configurational landscape metrics, the former representing the proportions of the different habitat types in the landscape and the latter the spatial arrangement of habitat patches and connectivity between them (McGarigal & McComb 1995). For each of the five focal scales, we calculated four compositional metrics: primary forest cover (PFC), secondary forest cover – initial stage (SFC1), intermediate stage (SFC2) and advanced stage (SFC3). In addition, we calculated four configurational metrics: edge density (ED), patch density (PD), mean nearest neighbour distance (MNND), and mean shape index (MSI). Landscape metrics were selected based on the information from previous fragmentation studies on bats (Cisneros et al. 2014; Cisneros et al. 2015; Klingbeil & Willig 2009, 2010; Meyer & Kalko 2008b; Rocha et al. *submitted*). All metrics were calculated using the R package "SDMtools" (VanDerWal et al. 2011) except MNND, which was calculated using the software QGIS. This metric corresponds to the mean of the shortest straight-lines distance between the focal patch (sampling site) and each of its nearest neighbour of the same class (McGarigal 2014). Therefore, when a sampling site for a given buffer had only one patch of primary forest we used the mean nearest neighbour distance of the next size buffer with at least two patches of primary forest.

Data Analysis

Influence of season and habitat type on bat abundance patterns

General linear mixed-effects models (GLMMs) were used to assess differences in the abundance of each species between seasons (dry and wet) and habitat types (interior, edge and matrix). All models were fitted with the "lme4" package in R (Bates 2010). The abundance of a given species was used as dependent variable (Poisson distribution, log-link function) and season and habitat type as predictors, implemented as an interaction effect. Models incorporated a random term accounting for the nested sampling design (site within location) and an offset with a site's total capture effort (i.e., log(number of mist-net hours); 1 mist-net hour [mnh] equals one 12-m net open for 1h). For each species, significance of the predictors was assessed with likelihood-ratio tests, and significant results were analysed further via multiple comparison tests with Tukey contrasts (adjusted *P*-values reported) using the R

package "*multcomp*" (Hothorn et al. 2007). Models were only developed for species with more than 30 captures, hence a total of fifteen species were analysed.

Relative importance of local and landscape-scale predictors of bat abundance

To examine the relative effects of local vegetation characteristics and landscape-scale metrics in shaping bat abundance patterns we again used Poisson GLMMs. Separate sets of models were performed for each focal scale and for each season. In all models, abundance of a given species was used as dependent variable and local and landscape metrics as predictors. As above, site nested within location was included as a random effect, and log(effort) was included as an offset. We used variance inflation factors (VIF) to test for multicollinearity among predictors (Dormann et al. 2013). We assumed that variables with VIF ≥ 6 were moderately redundant/collinear and should be excluded from analysis (Benchimol & Peres 2015). However, we had to dismiss this analysis because each scale had different variables with VIF < 6, which would not allow us to compare the results between scales. Results based on pairwise Pearson correlations were similar to the VIF analysis. Hence, we chose to proceed with the GLMMs using all the predictor variables to have comparable results between scales. Also, each variable represents specific ecological mechanisms that potentially influence bat abundance and discarding one of them could lead to biased estimates of the relative importance for the remaining predictors (Smith et al. 2009). To ensure robustness of the results, species were only modelled when more than 30 individuals were captured in each season, thus resulting in models for eight species. We ran all predictor subsets models with the "AICcmodavg" package (Mazerolle & Mazerolle 2015) and selected the best-fit models using Akaike's information criterion corrected for small sample sizes (AIC_c). Models were retained as best-fit models when $\Delta AIC_c \leq 2$, i.e. when the difference from the best model was $(\Delta_i) \leq 2$ (Burnham & Anderson 2002). Model averaging was used to obtain the parameter estimates of the predictors when more than one model had $(\Delta_i) \leq 2$. Finally, to determine the relative importance of each explanatory variable we performed a hierarchical partitioning (HP) analysis using the "hier.part" package (Nally & Walsh 2004), modified to incorporate a model offset – log(effort). HP is a regression technique that minimizes the influence of multi-collinearity among variables by considering all possible linear models and determining the independent contribution of each explanatory variable to the response variable (Chevan & Sutherland 1991; Mac Nally 2000). All analyses were conducted in R v3.1.3 software (R Development Core Team 2013).

To assess how consistently predictor variables were selected between seasons, we calculated a model consistency index, which measured the agreement of the variables and directions of effects among seasons (Gutzwiller & Barrow Jr 2001). High inter-seasonal variation in species-landscape relations represent a low model consistency and vice-versa. Following Bonthoux et al. (2013), model consistency was calculated as the number of common variables with the same direction of effect between the dry season and the wet season, divided by the total number of landscape variables contained in the best-fit models.

Results

Based on a total sampling effort of 18650 mnh, 10726 mnh in the wet season and 7923 mnh in the dry season, we captured 3827 phyllostomids and 272 *P. parnellii*. Of those, 1799 phyllostomids representing 39 species and 5 subfamilies, as well as 114 *P. parnellii* were captured in the dry season, whereas 2028 phyllostomids from 41 species and 5 subfamilies, and 158 *P. parnelli* were caught in the wet season. Only six species were not captured in both seasons (Table S3): *Carollia castanea* and *Micronycteris schmidtorum* - only captured during the dry season - and *Glyphonycteris sylvestris, Lampronycteris brachyotis, Phyllostomus hastatus* and *Vampyressa pusilla* - only captured during the wet season. Fifty-six individuals, 25 in the dry season and 31 in the wet season, were recaptured at the same site in the same season and were not considered in the analysis.

Influence of season and habitat type on bat abundance patterns

Abundance patterns were variable between species and habitat types (Figure 3). Of the fifteen species analysed, eleven species (*Artibeus cinereus, Artibeus concolor, Artibeus lituratus, Artibeus obscurus, Carollia brevicauda, Carollia perspicillata, Phyllostomus elongatus, Pteronotus parnellii, Rhinophylla pumilio, Trachops cirrhosus* and *Tonatia saurophila*) had a significant effect for the Season x Habitat type interaction (Table S4). When the effect of season and habitat type was analysed separately, nine species (*A. cinereus, A. concolor, A. lituratus, A. obscurus, C. brevicauda, C. perspicillata, P. elongatus, T. cirrhosus* and *T. saurophila*) showed a significant effect for season and eight species (*A. concolor, A. lituratus, C. brevicauda, C. perspicillata, Lophostoma silvicolum, R. pumilio, T. cirrhosus* and *T. saurophila*) for habitat type (Table S4). *Lophostoma silvicolum* was the only species that responded only to habitat type, whereas all the other species were also influenced by season. However, when multiple pairwise comparisons were conducted to assess the seasonal differences in capture rates across the different habitat types only five of these species (*A. concolor, A. obscurus, A. lituratus, C. perspicillata* and *P. parnellii*) showed significant effects (Figure 3; Table S5). Seasonal differences in abundances were evident across all habitat types. The abundance of *C. perspicillata* was significantly higher in the dry season for all the three modified habitat types (fragment, edge and matrix sites). *A. concolor* and *A. obscurus* showed abundance differences only for edge and matrix sites, with higher capture rates in the dry season for both habitat types. *A. lituratus* and *P. parnellii* had higher capture rates in the dry season for matrix and fragment sites, respectively. Although the results were not significant based on the post hoc tests, four species had relatively different capture rates between seasons (Figure 3). Specifically, *Mimon crenulatum* and *Phyllostomus elongatus* had greater captures rates in the dry season than in the wet season in continuous forest, while *Tonatia saurophila* showed higher capture rates in the wet season. *Artibeus cinereus* showed similar patterns to *A. concolor* and *A. obscurus* but the effects were non-significant, likely due to the low number of captures in each habitat type.

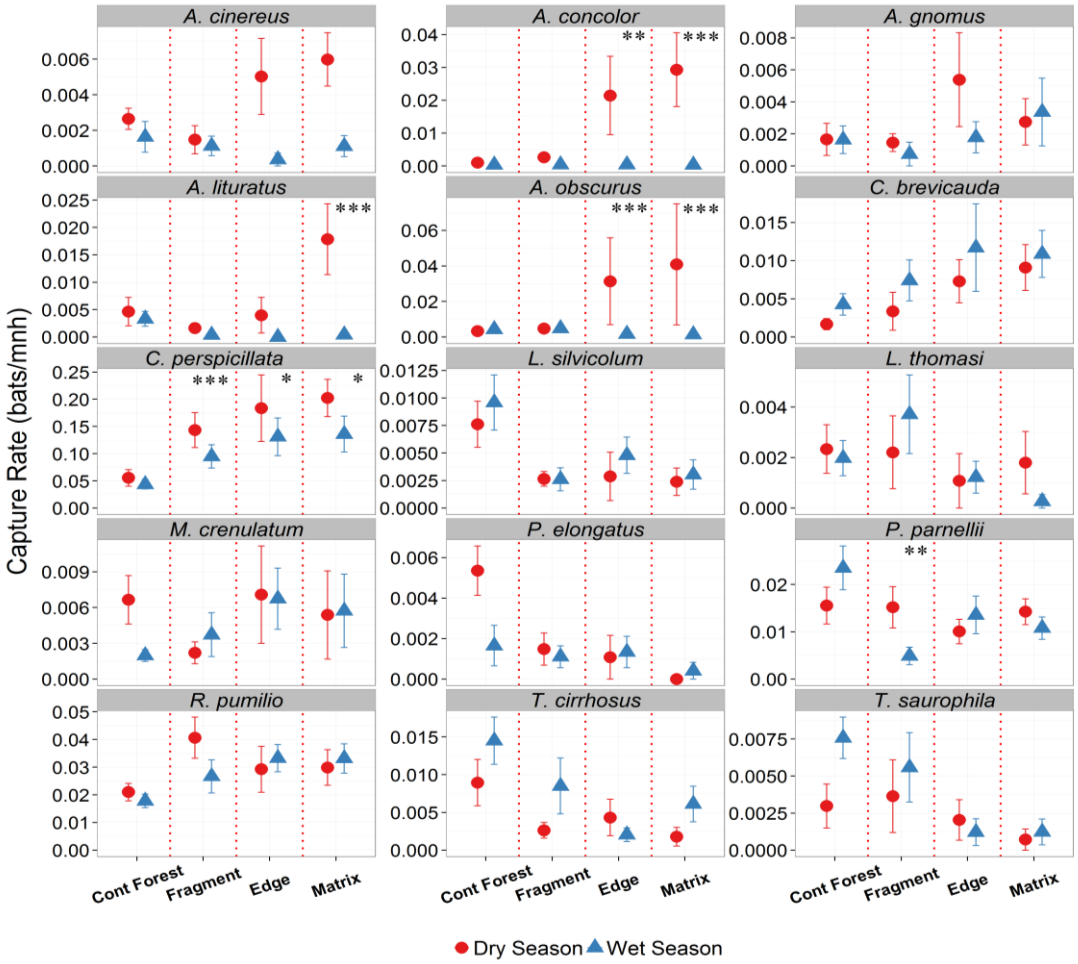


Figure 3. Comparison of mean (± SE) capture rate (bats/mnh) between seasons across different habitat types in the BDFFP landscape. Significant seasonal differences in capture rates based on multiple pairwise comparisons are indicated as: *** $P < 0.001$, ** $P < 0.01$ and * $P < 0.05$.

Relative importance of local and landscape-scale predictors of bat abundance

Relationships between species abundances and local vegetation structure and landscape characteristics were both season-specific and scale-dependent (Figure 5; Table S6).

Compositional metrics were overall more important in the dry season, whereas local-scale and configurational metrics played a more important role in the wet season. The way that species responded to these metrics varied between frugivorous and animalivorous species. Frugivores showed a stronger association with compositional metrics in the dry season, with the exception of *R. pumilio* which showed a strong association with configurational metrics. In the wet season, responses were very variable, with some species responding more to local vegetation structure (*A. obscurus* and *C. brevicauda*) and others responding more to configurational and compositional metrics (*C. perspicillata* and *R. pumilio*). Animalivorous species showed similar patterns in both seasons, having a strong

association with compositional metrics (*M. crenulatum* and *P. parnellii*) and configurational metrics (*L. silvicolum*) in both seasons. The only exception to this was *T. cirrhosus* which responded more to configurational metrics in the wet season, whereas in the dry season it showed relationships with local, compositional and configurational metrics.

A metric-specific analysis revealed that within compositional and configurational metrics patterns were very variable, with frugivorous species representing the group with larger variation in model consistency between seasons. Model consistency values averaged 38.4% (SD=23.8) for all eight species, 42% (SD=35.5) for the frugivores and 34.9% (SD=5) for animalivores. However, values ranged widely from 0% (no common landscape components and direction of effects between seasons – *A. obscurus*) to 71% (more than half of the landscape components and direction of effects in common between seasons – *Carollia* spp.) (Figure 4; Table S8).

Frugivorous species responded always negatively to PFC and positively to SFC3, whereas animalivores tended to respond positively to PFC and negatively to SFC3 (Table S6). *M. crenulatum* was the exception, showing a positive association with both metrics in the wet season and a strong positive association with SFC2 in the same season. In relation to configurational landscape metrics, frugivorous species responded, in general, positively to ED and MNND, while animalivorous species responded negatively to both metrics, with the exception once again of *M. crenulatum* which was positively associated with both metrics in the wet season. The abundance of two frugivores (*A. obscurus* and *C. brevicauda*) was more commonly associated with landscape metrics in the dry season, while in the wet season it shifted to a stronger association with local vegetation structure. *A. obscurus* was associated with all compositional metrics in the dry season while *C. brevicauda* was associated with two compositional metrics (PFC and SFC3) and with all configurational metrics, but only at the largest and the smallest spatial scales. *C. perspicillata* showed similar patterns between seasons, being positively associated with ED at the smallest scale and negatively associated with PFC at intermediate scales (500, 750 and 1000m). However, in the dry season it was also negatively associated with PFC at the largest scale (1500m) and positively associated with SFC3 at intermediate scales, while in the wet season there was only a positive association with SFC3 at the largest scales (1000 and 1500m). *R. pumilio* was associated with configurational characteristics (especially with ED, PD and MNND) in the dry season, but in the wet season was more commonly associated with compositional characteristics, presenting a strong positive association with ED and a strong negative association with PFC. As for animalivorous species, *L. silvicolum* was more commonly associated with configurational characteristics in the dry season, responding negatively to PD and MNND. In the wet season, patterns were similar, although compositional characteristics were also important for the smallest and largest scales. In the case of *M. crenulatum*, abundance was strongly associated with compositional characteristics in both seasons. In the dry season it responded more to PFC and to SFC3, and in the wet season responded more to SF2. *T. cirrhosus* showed a strong and positive association with vegetation characteristics and with MSI in the dry season and a stronger and negative association with configurational characteristics (ED and MNND) in the wet season. Lastly, abundance of *P. parnellii* was more commonly associated

with compositional characteristics for the smallest and intermediate scales (250, 500 and 750m) in the dry season and for intermediate to larger scales (≥ 500m) in the wet season. Configurational characteristics (ED, PD, MNND and MSI) were of greater importance at the smallest scale in the wet season, while in the dry season only the configurational characteristic MNND was associated at intermediate (500m) and large scales (≥ 100m).

Due to highly scale-specific results, general patterns as to which metric was most important at each spatial scale were hard to identify (Figure 5). Compositional and configurational landscape metrics were selected at all scales for both ensemble without any clearly discernible patterns, whereas local-scale vegetation structure showed a more consistent selection across all scales for frugivorous species. However, when focusing only on the variables with the greatest independent effect some interesting patterns emerged (Table S6). SFC1 and ED were associated with abundance more often at the smallest scales (250 and 500m) in both seasons. SFC3 commonly had a stronger effect at the smallest scale (250m) in the wet season, whereas in the dry season it was mostly associated with the larger spatial scales. SFC2 explained more variance in the wet season and was associated with abundance at all scales. PFC and LVS were associated with abundance at all scales and in both seasons. However, in the dry season, PFC was never strongly associated with abundance at the smallest scale and LVS at the largest scale (1500m). MNND showed similar patterns in both seasons and was related with abundance at intermediate to large spatial scales (≥ 500m). PD and MSI were only rarely associated with abundance, not showing any clear patterns.

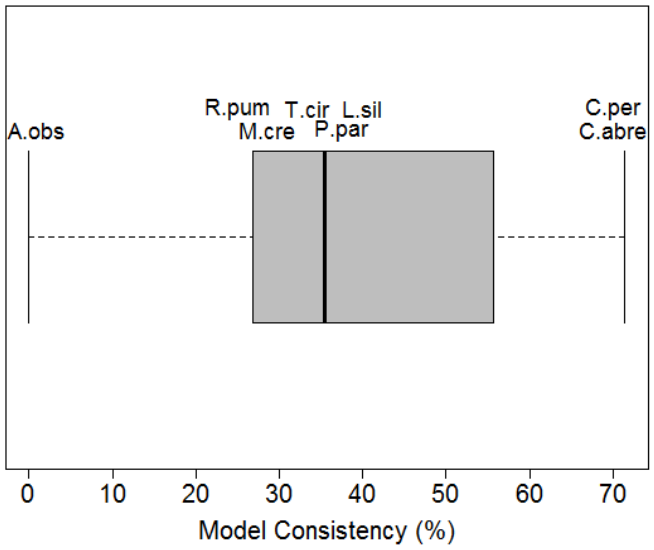
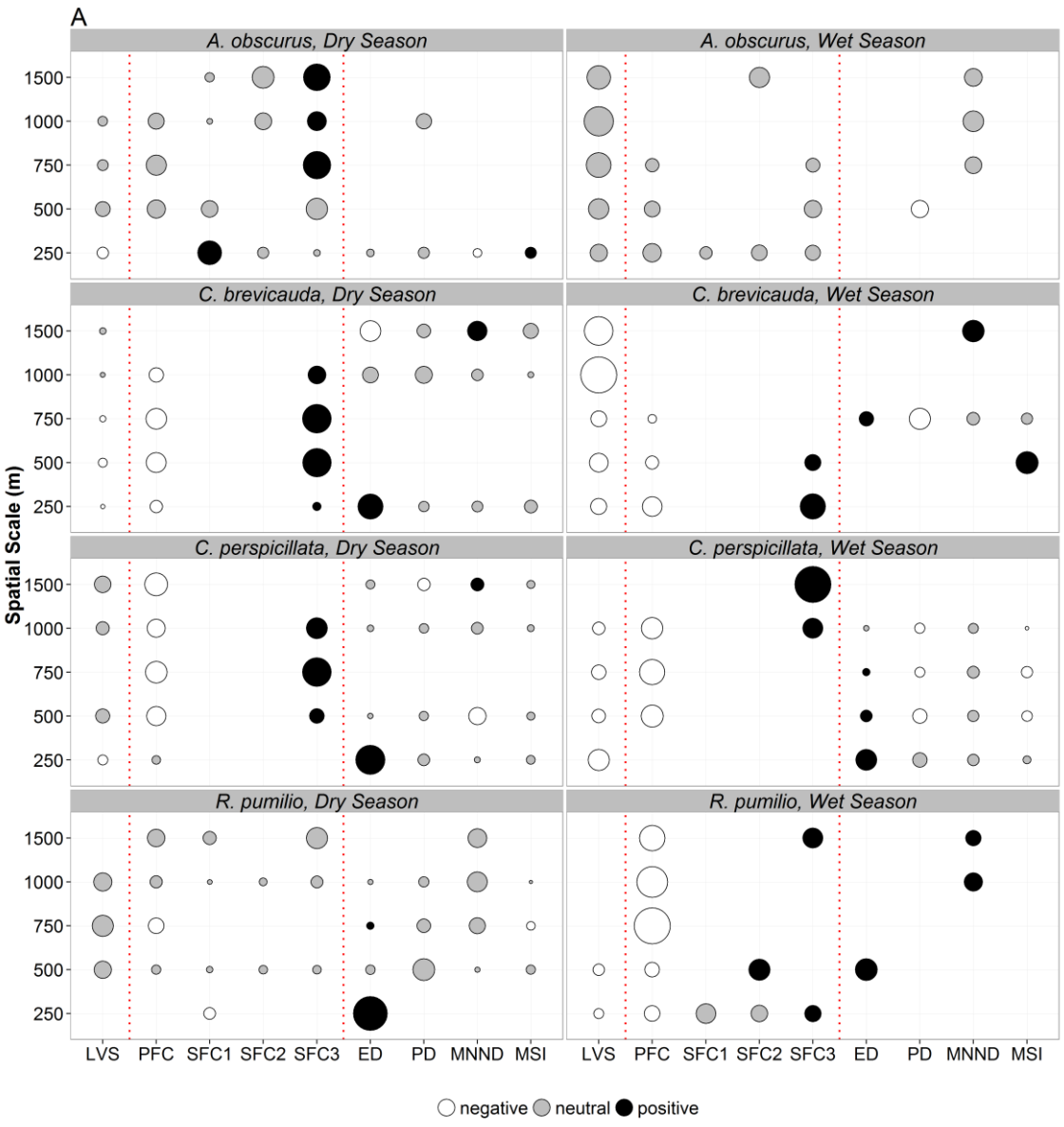


Figure 4. Box-and-whisker-plot showing the percentage of model consistency between seasons for bat-landscape relationships for eight species of bats (A. obs - *Artibeus obscurus*; C. per - *Carollia perspicillata*; C. abre - *Carollia brevicauda*; L. sil - *Lophostoma silvicolum*; M. cre - *Mimon crenulatum*; R. pum - *Rhinophylla pumilio* T. cir - *Trachops cirrhosus*; P. par - *Pteronotus parnellii*).


A
A. obscurus, Dry Season
A. obscurus, Wet Season
C. brevicauda, Dry Season
C. brevicauda, Wet Season
C. perspicillata, Dry Season
C. perspicillata, Wet Season
R. pumilio, Dry Season
R. pumilio, Wet Season
Spatial Scale (m)
1500
1000
750
500
250
LVS
PFC
SFC1
SFC2
SFC3
ED
PD
MNND
MSI
negative
neutral
positive

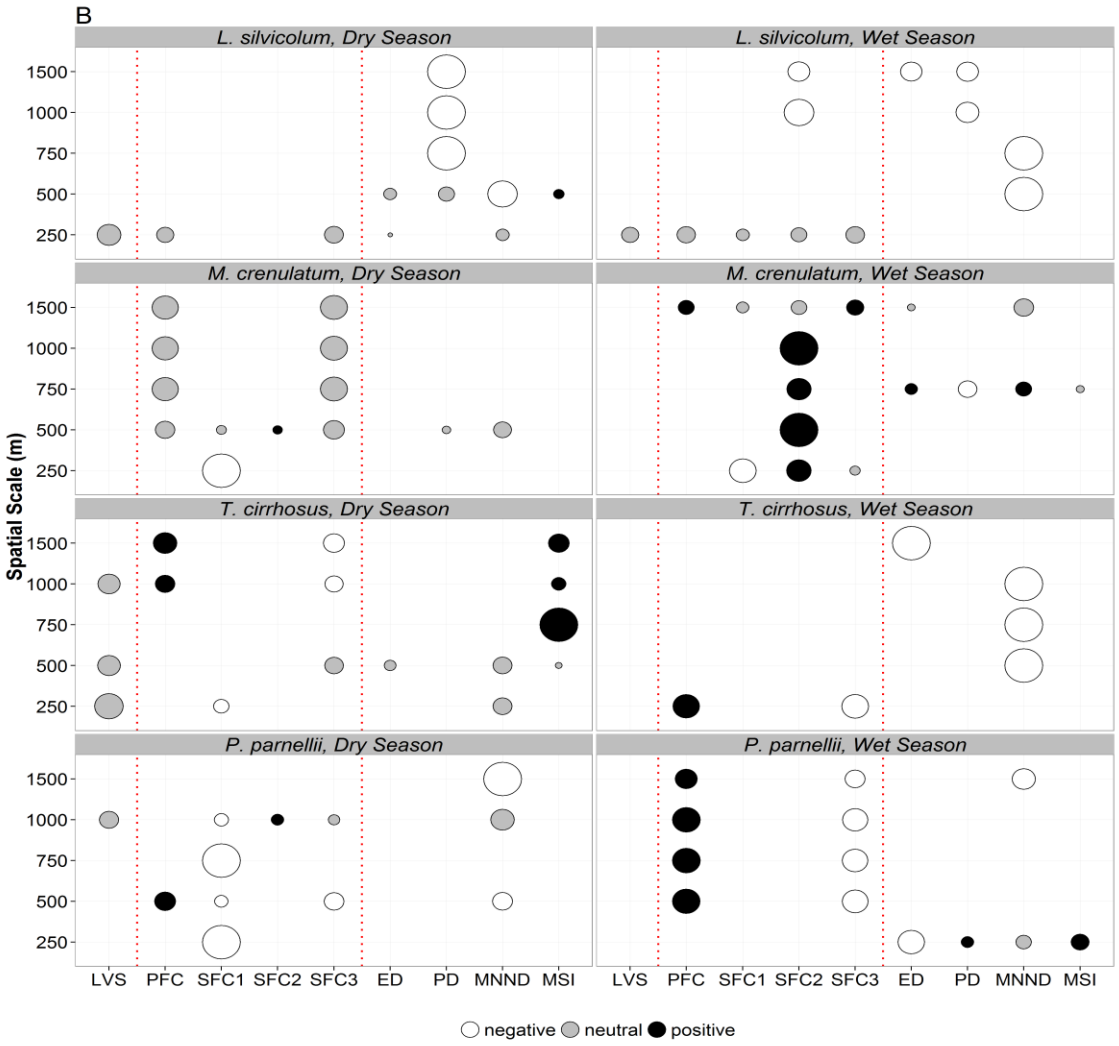


Figure 5. Variation explained by local- and landscape-scale attributes for each combination of season and scale for eight bat species captured in the BDFFP landscape. **A -** frugivores: *Artibeus obscurus*, *Carollia perspicillata*, *Carollia brevicauda* and *Rhinophylla pumilio*; **B -** animalivores: *Lophostoma silvicolum*, *Mimon crenulatum*, *Trachops cirrhosus*, *Pteronotus parnellii*. Circle size is proportional to the percentage independent contribution of the respective predictor variable on species abundance as determined by hierarchical partitioning. Colour represents the direction of the relationship based on the unconditional 95% CIs of the most parsimonious generalized linear mixed models (ΔAIC_c <2), where neutral represents a non-significant effect and positive/negative represents a significant effect and the respective direction of the effect. In each panel, local vegetation structure (LVS), compositional landscape metrics (PFC - primary forest cover; SFC1 - initial secondary forest cover; SFC2 - intermediate secondary forest cover; SFC3 - advanced secondary forest cover) and configurational landscape metrics (ED - edge density; PD - patch density; MNND - mean nearest neighbour distance; MSI - mean shape index) are separated by vertical dotted lines.

Discussion

We predicted that species would respond differently to landscape structure in each season and that these responses would be scale- and species-specific. These assumptions were made based on the diverse biological and ecological traits of bats and in view of the differences in food availability and distribution between wet and dry seasons, which are affected by landscape characteristics. Responses were scale-dependent, species-specific, and seasonal, and were affected by vegetation structure, and compositional and configurational metrics to varying degrees. Landscape-scale were more important than local-scale in modulating the responses of bats, although the latter was associated with two frugivores in the wet season. Nevertheless, our results did not support all of our predictions. Frugivores showed a more distinctively seasonal pattern than animalivores, responding in the dry season more to compositional metrics and more to local and configurational metrics in the wet season. Animalivorous species showed similar patterns in both seasons, responding to the same group of metrics in the wet and dry season. Overall, secondary forest cover was positively associated with the abundance of frugivores while negatively associated with the abundance of animalivores, with responses being more marked for advanced secondary forest.

Influence of season and habitat type on bat abundance patterns

Capture rates were variable between seasons, with some species showing a clear seasonal pattern. Differences in abundance occurred mostly in modified habitats (fragments, edge and matrix), probably due the different chronology of flowering and fruiting events in the secondary forest matrix. In continuous *terra firme* forest, the type of forest present at the BDFFP, fruiting pulses usually occur in the early wet season (Haugaasen & Peres 2005) and consequently declines in frugivore abundances in primary forest are expected during the dry season (Ortêncio-Filho et al. 2014). The reduction in food availability can lead to a shift of frugivores from primary to secondary forest, where fruit availability can be less seasonal (Barlow et al. 2007b). Bentos et al. (2008) showed that at the BDFFP some *Cecropia* spp. and *Vismia* spp., which are the dominant pioneer trees in the secondary forest matrix, have their flowering and fruiting peaks during the dry season. Due to greater food availability, secondary forest may be a more suitable habitat for some small generalist frugivores (de la Peña-Cuéllar et al. 2012; DeWalt et al. 2003; Faria 2006), which could lead to a change in their preferred foraging habitat during the dry season. It was already shown in other areas that monkeys and birds shift their foraging habitat to regrowth forests when resources in mature forests become scarce (Bowen et al. 2007). Despite this, none of the frugivorous bats showed an increase in captures rates in continuous forest or in the fragments during the wet season, when food availability is higher. An increase in fruit availability in other forest types (e.g. *várzea* forest) in comparison with *terra firme* forests (Haugaasen & Peres 2005; Pereira et al. 2010) could explain the absence of this pattern. Bobrowiec et al. (2014) showed that a drop in the abundance of *Carollia* spp in *terra firme* and a simultaneous increase in abundance of the same species in *várzea* could indicate seasonal movements between these different forest types. Several studies

on birds also have documented a dominant effect of food availability on habitat selection (Burke & Nol 1998; Naoe et al. 2011; Studds & Marra 2005). Therefore, such inter-habitat movements to other areas in the landscape could mask the supposed increase in bat abundances in continuous forest during the wet season.

Seven of the eight frugivores analysed showed seasonal patterns whereas only three of six animalivores showed differences between seasons. Compared with temperate species, many tropical insects tend to have long activity periods with less marked seasonal pulses and with more constant abundances throughout the year, especially in areas lacking a pronounced dry season (Hamer et al. 2005; Wolda 1988). However, some studies indicate that insect availability is higher during the rainy season in the Neotropics (Beja et al. 2010; Ortêncio-Filho et al. 2014). This fact can explain why some animalivores, although not significantly so, had high abundances in continuous forest during the wet season (*Tonatia saurophila)* and other species had during the dry season (*Mimon crenulatum* and *Phyllostomus elongatus)*. Detailed studies on the dietary composition of Neotropical insectivorous bats are necessary in order to know which insect families/species are present in each bat species' diet and how they are related to seasonal changes in abundance and availability of arthropods. Similarly, the lack of studies at BDFFP on the insect and fruit abundance, as well on the diet of animalivorous and frugivorous bats, only allowed speculative interpretations because differences in availability of food resources and bats diets can occur between regions. Contrary to the other species, *C. perspicillata* and *P. parnellii* had higher abundances in fragments in the dry season. Fragments in our study only comprised areas with a maximum of 100ha, i.e. much less than the known home range of *Carollia* spp. *Carollia* species can have a home range above 1000ha (Bernard & Fenton 2003) and due to their generalist diet and habitat affinities (Bobrowiec et al. 2014; Ortêncio-Filho et al. 2014) can easily use resources from the secondary forest. *P. parnellii* is an aerial insectivore capable of foraging in narrow-space areas (Denzinger & Schnitzler 2013). Morphological adaptations to flight in dense understory vegetation (de Oliveira et al. 2015; Denzinger & Schnitzler 2013), may allow both *C. perspicillata* and *P. parnellii* to take advantage of secondary forest areas for foraging and use primary forests as roosting sites.

Effects of seasonality on bat abundance responses to local and landscape-scale predictors

Seasonality affected the responses of bats to local and landscape metrics, with both groups of metrics playing an important role in explaining how fragmentation affects bat abundances. As suggested by the results of model consistency, which ranged from 0% to 71% and averaged 38.4%, responses varied substantially between seasons. The relative importance of different predictor variables and the magnitude of their effect were dependent on the season and species, in agreement with the findings of Klingbeil and Willig (2010) and Cisneros et al. (2015). Similarly, Vergara and Marquet (2007) showed that the magnitude of the effects of landscape metrics in a bird species were dependent on season. Even though fragment-matrix contrast at the BDFFP is low and distances between fragments and continuous forest are relatively small, species were influenced by different environmental filters that differ between seasons and benefit bat species depending on their biological and ecological traits

(Farneda et al. 2015). Both ensembles, frugivores and animalivores, responded differently to local, compositional and configurational metrics and no clear patterns regarding responses at different spatial scales emerged. In a parallel study conducted at the BDFFP, which used the same data, yet focused on responses at the assemblage-level, Rocha et al. (*submitted*) showed that the direction of effect for species richness and total abundance was scale-dependent, with e.g. species richness and total abundance being positively correlated with edge density at the smallest spatial scales and negatively correlated at larger scales.

The low captures rates of most species during our study only allowed analysis to focus on the most abundant species and consequently on more generalist species. Therefore, most of the rare and specialist bat species that depend exclusively on primary forest were not included and should be considered in future studies involving seasonality.

Frugivore ensemble

In the dry season, frugivores responded more to compositional metrics whereas during the wet season local and configurational metrics were more important. *R. pumilio* was an exception as it showed the opposite pattern. Secondary forest can have greater fruit availability than primary forest during the dry season (Bentos et al. 2008; Haugaasen & Peres 2005; Ortêncio-Filho et al. 2014), influencing the responses of frugivores that rely on these resources. All frugivores were positively associated with advanced secondary forest cover (SFC3, age $\geq$ 16 years) and negatively associated with primary forest cover (PFC), supporting the assumption that some generalist frugivores prefer regrowth forests as foraging habitat in fragmented landscapes (Klingbeil & Willig 2009, 2010; Montaño-Centellas et al. 2015).

For *R. pumilio*, overall, all configurational metrics were important during the dry season, with abundance being positively associated with edge density at small scales. This suggests that although it can exploit resources in secondary forest, the spatial organization of primary forest patches and distance between them play an important role. These could be related to the small home range of this species, which ranges from 2.5ha to 16.9ha (Henry & Kalko 2007) and to the fact that small scale edges can provide more foraging opportunities and improve connectivity between roosting and foraging areas for this species (Kalda et al. 2015; Rocha et al. *submitted*). In the wet season, *R. pumilio* responded more to compositional metrics. Female bats lactate at the onset and during the rainy season (Estrada & Coates-Estrada 2001; Henry & Kalko 2007), increasing their food intake during this period (Henry & Kalko 2007). Hence, during this period bats will be more dependent on food availability and distribution, responding more to compositional metrics.

Carollia perspicillata was the only species that responded more to landscape composition (negatively to PFC and positively to SFC3) than to the other group metrics in both the wet and dry season. In a study conducted in a fragmented landscape characterized by continuous forest surrounded by matrix of agriculture, development and logging areas, in unflooded (*terra firme*) Amazonian rainforest, Klingbeil and Willig (2010) found a consistent

negative response to primary forest (indicating a preference for secondary forest), regardless of season, for this species. In our study, it represented more than 50% of all bat captures (Table S3), demonstrating its success in exploiting the resources of secondary forest throughout the year. Fruit preferences can influence the foraging behavior of species, and therefore can affect how they respond to landscape structure. *C. perspicillata* incorporates great proportions of *Vismia* and *Cecropia* (the dominant tree genera in the BDFFP secondary forest matrix) in its diet (Fleming 2004; Thies & Kalko 2004), explaining why its abundance was positively influenced by the amount of secondary forest present in the landscape.

In the wet season, responses were more species-specific. *A. obscurus* and *C. brevicauda* responded more to local vegetation structure than to landscape metrics in this season. Due to the high fruit availability during wet season bats don't need to travel long distances for foraging and consequently may be more dependent on the local-scale. Local vegetation structure was negatively associated with the number of *Vismia* and *Cecropia* trees (Table S2), which may explain why both species were negatively associated to local vegetation structure. This relation indicate that these tree genera may also play an important role in the wet season. Cisneros et al. (2015) found that the landscape metrics only influenced the metacommunity structure of the frugivore ensemble in the dry season and suggested that environmental characteristics at the local scale could be more important in the wet season. Our findings for both *A. obscurus* and *C. brevicauda* align with these assumption, and demonstrated that local vegetation structure may play a more important role in the wet season for these two species.

In the wet season pregnant and lactating females bats can reduce their flight durations between foraging and roosting sites in order to compensate for the metabolic cost of producing milk or the increased weight of carrying a fetus (Charles-Dominique 1991; Klingbeil & Willig 2010). Moreover, males of some bats species (e.g. *A. jamaicensis*, *C. perspicillata*) invest time and energy defending roosts and harems during the breeding season (Kunz & Hood 2000), which could result in smaller home ranges due to the higher energetic demands (Klingbeil & Willig 2010). Therefore, the spatial scale at which bats respond may be smaller and more dependent on local vegetation structure in the wet season. The spatial variability of food resources during the wet season in BDFFP landscape is more heterogeneous and richer than in the dry season (see above) affecting the diet of frugivorous species. The diet of some frugivorous species changes throughout the year as the food availability of different plant species varies across the landscape (Da Silva et al. 2008). More studies are needed in order to understand how these complex relationships between forest types affects the frugivore ensemble.

Animalivore ensemble

In contrast to frugivores, animalivores showed a more similar pattern between wet and dry season. Three of the animalivorous species responded to the same group of metrics in both seasons, *L. silvicolum* to configuration and *P. parnellii* and *M. crenulatum* to composition, suggesting that for animalivores, seasonality and consequently the variability in resource availability may not play such an important role as it does for frugivores. This contrasts with

the findings of Klingbeil and Willig (2010), who found that abundance responses of animalivores to landscape structure differed between seasons, responding to landscape configuration in the dry season and to landscape composition in the wet season. However, their study was conducted in a more heterogeneous landscape, in which primary forest was surrounded by agricultural, logging and development areas, whereas the primary forest fragments at the BDFFP are surrounded by a more homogeneous matrix of secondary forest. Tews et al. (2004) found a positive correlation between habitat heterogeneity/diversity and insect species diversity. Hence, the BDFFP landscape could harbour a lower arthropod diversity and abundance than the matrix in Klingbeil and Willig (2010) study, and consequently show a less seasonal variation in prey availability. In our study, only *T. cirrhosus* showed seasonal variation in abundance, responding more to configurational metrics than composition in the wet season.

In the Neotropics, abundance of frugivores generally increases in fragmented or disturbed areas, whereas gleaning animalivores tend to decline (Meyer et al. *in press*). Although late successional secondary forest can have structural similarities to primary forest (Ferreira & Prance 1999), it can take decades or even centuries to resemble old-growth forests (Guariguata and Ostertag, 2001). In our study landscape, most of the secondary forest in the matrix is less than 30 years old (Carreiras et al. 2014) and consequently structurally less complex than adjacent continuous forest, constituting less suitable habitat for most gleaning animalivores due to insufficient roosting and prey resources (Meyer & Kalko 2008a). Therefore, most species will not be able to exploit the seasonal resource peaks that can occur in secondary forest and will be more dependent on primary forests. With the exception of *M. crenulatum*, all animalivorous species showed a negative association with secondary forest cover, edge density and mean nearest neighbour distance in both seasons. Usually, higher density of edges and distances between patches lead to a reduction in the quality of the landscape for species that have small home ranges and depend on primary forest. *M. crenulatum* responded mostly to landscape composition and showed a positive relation with secondary forest cover, especially with that of intermediate stages (SFC2, 6-15 years). Secondary forests of this age are structurally and compositionally very different from primary forest (Guariguata & Ostertag 2001) and do not offer suitable habitat conditions for most gleaners. However, our data indicate that *M. crenulatum* may be using secondary forest as foraging area or as flyways between food patches, and should be considered a generalist species in terms of habitat use. More information is nevertheless needed in order to understand if this species can really use sub-optimal habitats or if this is an artefact of our data caused by the low capture rates of this species and the overall low representation of intermediate-stage secondary forest in the landscape (less than 15% of all secondary forest).

As mentioned, *T. cirrhosus* responded more to configurational metrics in the wet season. Responses to configurational metrics occur usually during the season when food availability is lower, because bats need to visit habitat of lower quality (e.g. edges) and will be more dependent on the spatial arrangement and configuration of forest patches (Klingbeil & Willig 2010). *Trachops cirrhosus* is a gleaning animalivore that feeds mainly on small vertebrates, especially frogs, and insects (Kalko et al. 1999; Rodrigues et al. 2014). In the Central Amazon, the wet season is the period of highest frog abundance and juvenile recruitment (Menin et al. 2008; Watling & Donnelly

2002). Despite this, *T. cirrhosus* showed a greater dependence on configurational metrics in the wet season, suggesting that although frogs are consumed by the species at the BDFFP (Rocha et al. *in press;* Rocha et al. 2012), this prey group may not be as important for *T. cirrhosus* in this area. Alternatively, fragmentation could be affecting the phenology of its prey, leading to changes in the dietary habits of *T. cirrhosus*. Changes in dietary habitats in fragmented landscapes due to reduced availability of high-value food resources have been documented for other taxa such monkeys (Chaves et al. 2011). However, studies are needed in order to understand if fragmentation is really affecting the dietary habits of *T. cirrhosus*.

Conclusions

Most bat species analysed in this study showed seasonal changes in abundance. Furthermore, seasonality affected the responses of bats to local and landscape characteristics. Local-scale metrics were not as important as landscape-scale metrics, however, for some species vegetation structure modulated the ecological responses to fragmentation during the wet season. Differences in responses between seasons were likely a result of differential resource availability and abundance that was intensified by fragmentation. The magnitude of seasonal changes in resource availability can be affected by fragmentation, causing shifts in foraging strategy, and consequently the scale at which species respond to landscape characteristics, that are probably not necessary in unfragmented landscapes (Klingbeil & Willig 2010). Hence, it is necessary to understand how each species exploits the habitat and how its dietary habits are jointly affected by fragmentation and seasonality, especially since synergistic effects between fragmentation and seasonality may trigger cascading effects in plant-bat interactions, both directly via seed dispersal and pollination or indirectly via the control of herbivorous arthropods. For example, Naoe et al. (2011) found that seeds of tree species that fruit during the bird breeding season in fragmented areas were dispersed with less efficiency that in continuous forest areas.

In our study area, where the contrast between fragments and matrix is low, most of the species were able to use the secondary forest matrix to some degree. The conservation value of secondary forests in a future for which it is predicted that up to 40% of the Amazon forest will be lost by 2050 (Soares-Filho et al. 2006) is tremendous, and therefore knowledge about the ability of species to exploit the resources (food and roost) in secondary forest is fundamental to improve the extinction risk assessment for bat species (Bird et al. 2012). Also, secondary forest can be used as corridors to mitigate the impacts of deforestation, and allow the subsistence of frugivorous and animalivorous bat populations (Bobrowiec & Gribel 2010). Our results indicate that advanced successional stages of secondary forest constitute suitable habitats for frugivores but are not suitable for most gleaning animalivorous bats. Therefore, management actions should promote secondary forest regrowth and consequently minimize fragment - matrix contrast in order to maintain and improve habitat quality for bats. However, continuous primary forests are areas of unique value and are essential to the preservation of tropical biodiversity (Barlow et al. 2007a; Gibson et al. 2011), and so measures that prioritize the conservation of primary forest should prevail in conservation.

Finally, seasonality should be considered in management actions to guarantee that bats have the necessary resources during non-breeding and breeding seasons.

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Supplementary Materials

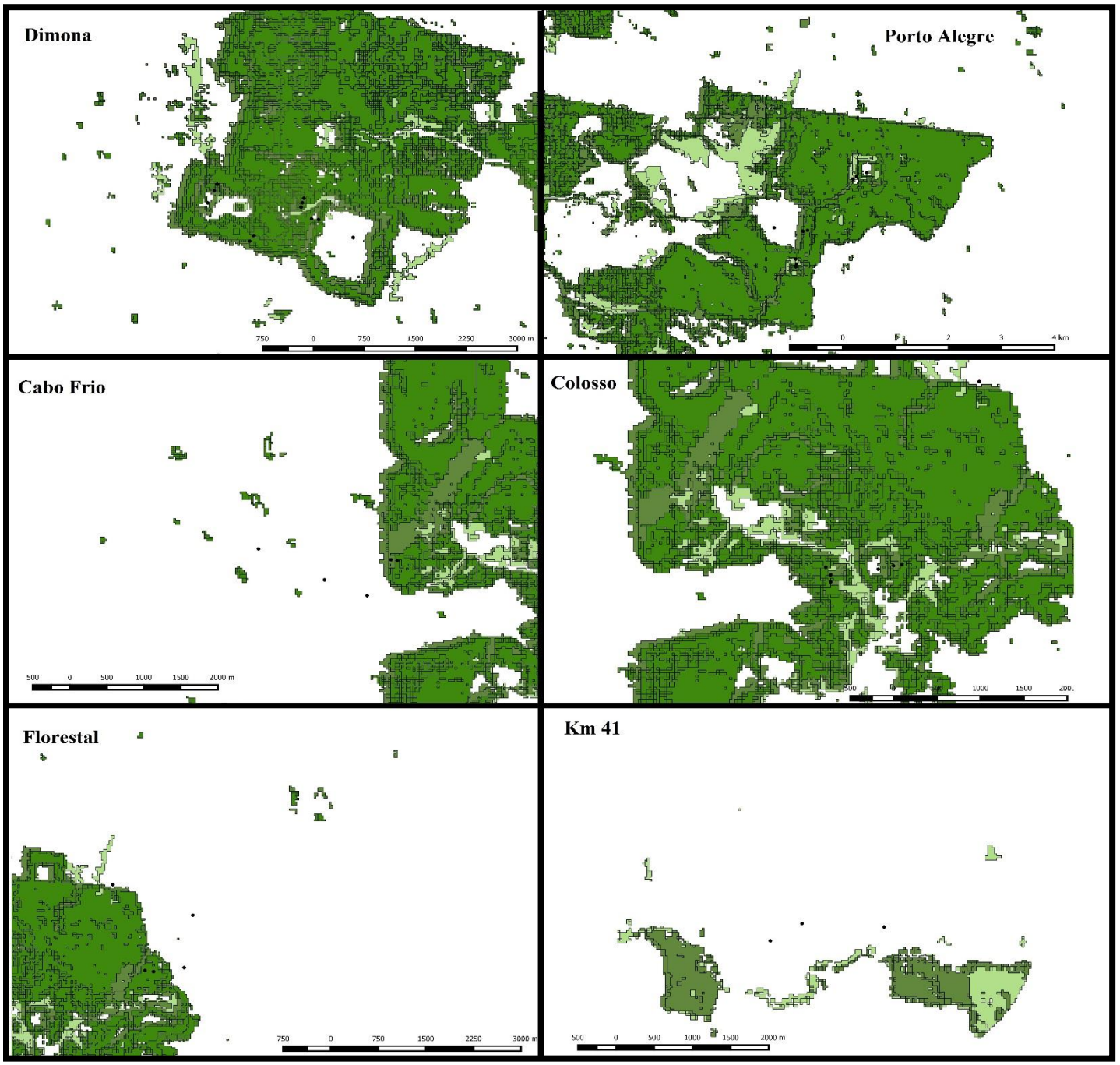

Figure S1. Map showing the distribution of the different successional stages of secondary forest for each reserve in the Biological Dynamics of Forest Fragments Project (BDFFP) study area, in the central Amazon. White represents primary forest cover and different shades of green (from light to dark) the different secondary forest cover (SFC) age classes (initial (≤ 5 years) – SFC1, intermediate (6-15 years – SFC2), advanced (≥ 16 years) – SFC3).

Table S1. Summary of local vegetation structure variables. CC = percent canopy cover, CH = canopy height (m), DBH = average (cm) of the DBH measures of trees ≥ 10 cm, L = number of lianas, P = number of palms, S = number of woody stems (DBH < 10 cm), T = number of trees (DBH ≥ 10 cm), VC = number of *Vismia* and *Cecropia* trees, VFD = vertical foliage density. Results are presented as mean ± 1SD. Taken from Rocha et al. (*submitted*).

Habitat category	CC	CH	DBH	L	P	S	T	VC	VFD
Continuous forest interior	85.4 ± 5.2	12.4 ± 3.2	24.8 ± 1.3	1.2 ± 0.4	14.4 ± 5.1	101.1 ± 27.8	10.9 ± 2.7	0.2 ± 0.4	519.4 ± 112.8
Continuous forest edge	78.6 ± 5.3	7.8 ± 1.8	17.7 ± 1.5	1.7 ± 1.2	5.7 ± 3.2	70.3 ± 10.7	11.3 ± 2.1	1.7 ± 0.6	455.3 ± 134.3
Continuous forest matrix	79.1 ± 0.3	8.6 ± 2.8	16.3 ± 1.5	1.7 ± 0.6	4.7 ± 2.1	83.7 ± 43	9.3 ± 1.2	2.3 ± 1.5	460.3 ± 164.1
100 ha fragment interior	83.6 ± 0.9	11.3 ± 1.6	23 ± 1.4	1	10.5 ± 6.4	92 ± 29.7	8	0	722.5 ± 98.3
100 ha fragment edge	74.2 ± 5.5	8.7 ± 0.6	17.5 ± 0.7	2.5 ± 0.7	4.5 ± 2.1	109.5 ± 13.4	11 ± 1.4	3	575 ± 89.1
100 ha fragment matrix	71.6 ± 2	7.1 ± 0.5	17 ± 1.4	2.5 ± 2.1	2 ± 2.8	105 ± 28.3	7.5 ± 0.7	2	463 ± 1.4
10 ha fragment interior	87.4 ± 1	9.7 ± 1.2	23 ± 3	2.3 ± 1.2	7 ± 1	96 ± 15.6	7.7 ± 0.6	0.7 ± 0.6	639 ± 53.7
10 ha fragment edge	79.6 ± 2.5	6.7 ± 0.6	20.7 ± 6.4	3 ± 1	4.7 ± 2.1	123.3 ± 54.2	8.7 ± 1.5	9.3 ± 10.2	438 ± 67.9
10 ha fragment matrix	76.5 ± 1.3	6.6 ± 1.5	14.3 ± 1.5	1.7 ± 2.1	2.7 ± 2.1	117.7 ± 32.1	8.3 ± 4.9	12.3 ± 9.3	362.7 ± 29.5
1 ha fragment interior	84.6 ± 2	7.6 ± 0.7	23.3 ± 3.8	2 ± 1	11 ± 5	88 ± 42.5	7.7 ± 0.6	0	547.7 ± 89.4
1 ha fragment edge	79.1 ± 10.2	7.1 ± 0.8	18 ± 3.6	2.3 ± 1.5	5 ± 4	130 ± 34.7	10 ± 2.6	2.3 ± 2.1	519 ± 24
1 ha fragment matrix	75.1 ± 6.7	7.3 ± 1.7	18.3 ± 2.3	3.3 ± 0.6	5 ± 3.6	95.3 ± 25.8	7.3 ± 2.3	4.3 ± 3.2	468.3 ± 137

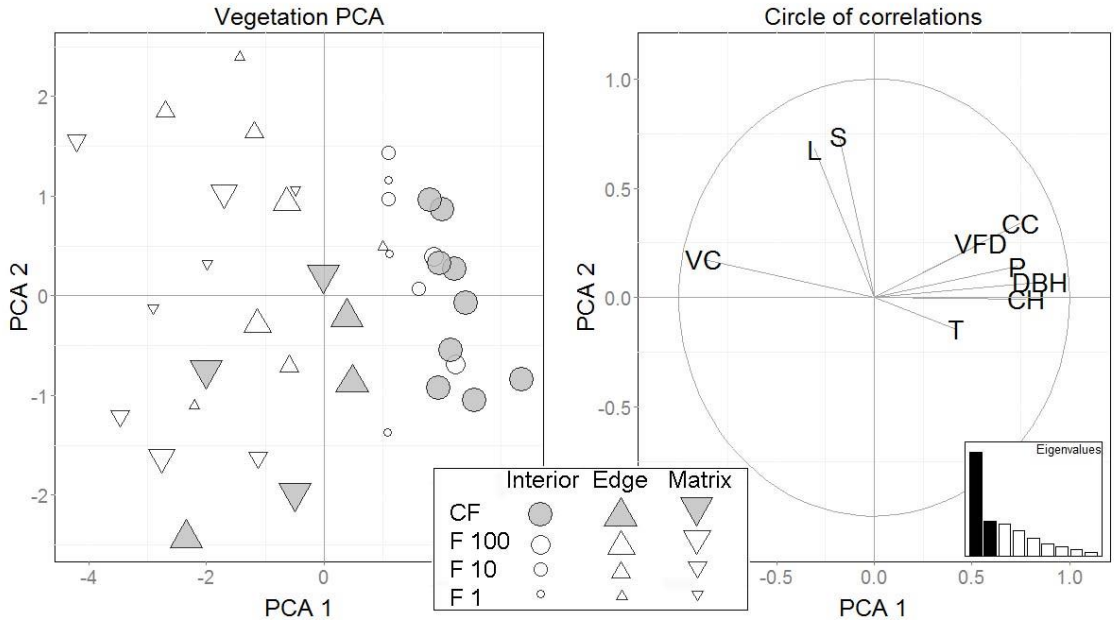

Figure S2. Principal component analysis examining the covariation between local vegetation structure variables. CC = canopy cover, CH = canopy height (m), DBH = average of the DBH measures of trees ≥10 cm, L = number of lianas, P = number of palms, S = number of woody stems (DBH <10 cm), T = number of trees (DBH >10), VC = number of *Vismia* and *Cecropia* trees, VFD = vertical foliage density.

Table S2. Variable loadings, eigenvalues and proportion of variance explained by the first two axes of a Principal Component Analysis (PCA) on the local vegetation structure descriptors. CC = canopy cover, CH = canopy height (m), DBH = average of the DBH measures of trees ≥10 cm, L = number of lianas, P = number of palms, S = number of woody stems (DBH <10 cm), T = number of trees (DBH >10), VC = number of *Vismia* and *Cecropia* trees, VFD = vertical foliage density.

Vegetation structure variables	**PCA 1**	**PCA 2**
CC	0.386	0.303
S	-0.092	0.657
T	0.216	-0.128
P	0.379	0.126
L	-0.157	0.605
VC	-0.448	0.156
DBH	0.436	0.064
CH	0.399	-0.005
VFD	0.280	0.222
Eigenvalue	3.8	1.3
% explained	42.02	14.2
Cumulative proportion	42.02	56.04

Table S3. Number of captures for each phyllostomid bat species and *Pteronotus parnellii* sampled in the BDFFP, Central Amazon, Brazil. Ensemble abbreviations: ANIM = animalivore; FRUG = frugivore; GLAN = gleaning animalivore; NECT = nectarivore SANG = sanguivore.

		Dry Season				Wet Season				
Taxon	**Ensemble**	**Cont. Forest**	**Fragment**	**Edge**	**Matrix**	**Cont. Forest**	**Fragment**	**Edge**	**Matrix**	**Total**
Phyllostomidae										
Ametrida centurio	FRUG	0	0	4	2	0	0	0	1	7
Anoura caudifer	NECT	0	0	1	0	1	1	1	1	5
Artibeus cinereus	FRUG	8	4	6	7	5	3	1	2	36
Artibeus concolor	FRUG	3	7	19	36	1	1	1	1	69
Artibeus gnomus	FRUG	5	3	6	3	5	2	4	9	37
Artibeus lituratus	FRUG	14	4	4	21	10	1	0	2	56
Artibeus obscurus	FRUG	10	12	32	46	13	13	3	5	134
Artibeus planirostris	FRUG	4	5	1	1	6	3	0	2	22
Carollia brevicauda	FRUG	5	9	9	10	13	20	30	37	133
Carollia castanea	FRUG	0	3	0	0					3
Carollia perspicillata	FRUG	168	381	201	240	132	256	353	405	2136
Choeroniscus minor	NECT	0	4	0	0	1	2	0	0	7
Chrotopterus auritus	ANIM	1	2	0	0	2	0	0	0	5
Desmodus rotundus	SANG	4	1	0	1	3	1	1	0	11
Glossophaga soricina	NECT	0	3	1	0	2	2	0	0	8
Glyphonycteris daviesi	ANIM	1	0	0	0	2	0	0	2	5
Glyphonycteris sylvestris	ANIM					1	0	0	0	1
Lampronycteris brachyotis	ANIM					0	1	0	0	1
Lonchophylla thomasi	NECT	7	6	1	2	6	10	3	0	35
Lophostoma brasiliense	ANIM	0	0	1	0	1	0	3	0	5
Lophostoma carrikeri	ANIM	1	1	2	0	0	0	0	1	5
Lophostoma schulzi	ANIM	2	1	0	0	2	1	1	2	9
Lophostoma silvicolum	ANIM	23	7	3	3	29	7	11	7	90

Mesophylla macconnelli	FRUG	12	2	1	1	4	3	1	0	24
Micronycteris hirsuta	ANIM	0	1	0	0	0	0	0	1	2
Micronycteris megalotis	ANIM	1	1	0	1	0	0	1	0	4
Micronycteris microtis	ANIM	2	1	0	1	3	2	2	4	15
Micronycteris schmidtorum	ANIM	0	1	0	0					1
Mimon crenulatum	ANIM	20	6	7	7	6	10	20	16	92
Phylloderma stenops	ANIM	1	3	0	1	6	0	3	2	16
Phyllostomus discolor	NECT	2	3	1	0	1	0	2	1	10
Phyllostomus elongatus	ANIM	16	4	1	0	5	3	3	1	33
Phyllostomus hastatus	ANIM					1	1	1	0	3
Platyrrhinus helleri	FRUG	0	0	2	0	0	0	0	1	3
Rhinophylla pumilio	FRUG	63	108	34	37	54	72	90	86	544
Sturnira tildae	FRUG	1	1	1	7	0	0	4	12	26
Tonatia saurophila	ANIM	9	10	2	1	23	15	4	3	67
Trachops cirrhosus	ANIM	27	7	4	2	44	23	4	14	125
Trinycteris nicefori	ANIM	2	0	0	0	2	2	2	2	10
Uroderma bilobatum	FRUG	0	1	2	0	0	0	0	2	5
Vampyressa pusilla	FRUG					0	0	1	0	1
Vampyriscus bidens	FRUG	3	3	0	1	7	2	1	2	19
Vampyriscus brocki	FRUG	0	1	0	0	0	1	1	0	3
Mormoopidae										
Pteronotus parnellii	ANIM	47	40	11	16	71	13	36	38	272
Total Captures		462	646	357	447	462	471	588	662	4095

Table S4. Results of the Likelihood ratio test for the abundance of each species between seasons (dry and wet) and habitat types (interior, edge and matrix). Significant (adjusted P < 0.05) results are highlighted in bold.

	Interaction (Season x Habitat Type)			**Season**			**Habitat Type**		
Species	**Pr (>Chisq)**	**Chisq**	**Df**	**Pr (>Chisq)**	**Chisq**	**Df**	**Pr (>Chisq)**	**Chisq**	**Df**
Artibeus cinereus	**0.0051**	20.239	7	**0.0005**	11.98	1	0.6498	1.64	3
Artibeus concolor	**< 2.2e-16**	134.76	7	**< 2.2e-16**	111.27	1	**0.0022**	14.55	3
Artibeus gnomus	0.3649	7.6459	7	0.4975	0.46	1	0.271	3.91	3
Artibeus lituratus	**4.626e-11**	62.568	7	**4.735e-08**	29.82	1	**0.0036**	13.55	3
Artibeus obscurus	**< 2.2e-16**	134.71	7	**< 2.2e-16**	76.88	1	0.9863	0.14	3
Carollia brevicauda	**0.0009**	24.628	7	**0.0006**	11.75	1	**0.004**	13.32	3
Carollia perspicillata	**1.96e-10**	59.431	7	**3.719e-11**	43.76	1	**0.007**	12.10	3
Lophostoma silvicolum	0.2218	9.4524	7	0.5401	0.38	1	**0.0387**	8.38	3
Lonchophylla thomasi	0.061	13.492	7	0.7867	0.07	1	0.0502	7.81	3
Mimon crenulatum	0.2097	9.644	7	0.6297	0.23	1	0.3915	3.00	3
Phyllostomus elongatus	**0.0437**	14.453	7	**0.0266**	4.92	1	0.0573	7.51	3
Pteronotus parnellii	**0.0007**	25.28	7	0.6546	0.20	1	0.2929	3.72	3
Rhinophylla pumilio	**0.0068**	19.498	7	0.2262	1.46	1	**0.016**	10.33	3
Trachops cirrhosus	**0.0006**	25.782	7	**0.0068**	7.32	1	**0.0168**	10.22	3
Tonatia saurophila	0.0263	15.871	7	**0.0319**	4.60	1	**0.0362**	8.53	3

Table S5. Results of multiple pairwise comparisons of GLMMs testing for differences in abundance of eleven species across the two seasons (dry and wet) and across the four habitat types (continuous forest, fragment, edge and matrix). Significant (adjusted P < 0.05) results are highlighted in bold.

Wet vs Dry	**Species**			
	Artibeus cinereus			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	-0.7019	0.6124	-1.146	0.942
Fragment	-0.3157	0.7638	-0.413	1.000
Edge	-2.5690	1.0801	-2.378	0.237
Matrix	-2.0293	0.8018	-2.531	0.170
	Artibeus concolor			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	-1.1126	1.1544	-0.964	0.9737
Fragment	-1.9607	1.0692	-1.834	0.5527
Edge	-3.9641	1.0235	-3.873	**0.0023**
Matrix	-4.2974	1.0157	-4.231	**< 0.001**
	Artibeus lituratus			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	-3.425e-01	4.173e-01	-0.821	0.9881
Fragment	-1.423e+00	1.146e+00	-1.241	0.8915
Edge	-2.009e+01	7.787e+03	-0.003	1.0000
Matrix	-3.153e+00	7.465e-01	-4.224	**< 0.001**
	Artibeus obscurus			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	0.2542	0.4206	0.604	0.9983
Fragment	0.0499	0.4006	0.125	1.0000
Edge	-3.2189	0.6027	-5.341	**< 0.001**
Matrix	-2.9699	0.4724	-6.287	**< 0.001**
	Carollia brevicauda			
	Estimate	Std. Error	z value	Pr(>|z|)

Wet vs Dry	**Species**			
	Phyllostomus elongatus			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	-1.262	0.5638	-2.239	0.275
Fragment	-0.3125	0.7603	-0.411	1.000
Edge	0.2856	1.1515	0.248	1.000
Matrix	18.8891	1024.0003	0.018	1.000
	Rhinophylla pumilio			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	-0.1637	0.1846	-0.887	0.9862
Fragment	-0.4195	0.1537	-2.730	0.1084
Edge	0.1519	0.1993	0.762	0.9944
Matrix	0.1014	0.1982	0.511	0.9996
	Trachops cirrhosus			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	0.4345	0.2467	1.761	0.6131
Fragment	1.1339	0.4340	2.612	0.1338
Edge	-0.8602	0.7095	-1.212	0.9165
Matrix	1.1423	0.7571	1.509	0.7781
	Tonatia saurophila			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	0.9323	0.3932	2.371	0.229
Fragment	0.4055	0.4083	0.993	0.971
Edge	-0.0918	0.8682	-0.106	1.000
Matrix	0.2973	1.1567	0.257	1.000
	Pteronotus parnellii			
	Estimate	Std. Error	z value	Pr(>|z|)

Cont. Forest	0.945	0.5082	1.860	0.5456
Fragment	0.7836	0.3892	2.013	0.4401
Edge	0.3134	0.372	0.843	0.9886
Matrix	0.5993	0.3618	1.656	0.6858
	Carollia perspicillata			
	Estimate	Std. Error	z value	Pr(>|z|)
Cont. Forest	-0.2435	0.1156	-2.106	0.3218
Fragment	-0.3989	0.0811	-4.919	**<0.001**
Edge	-0.2696	0.088	-3.065	**0.0295**
Matrix	-0.2585	0.0833	-3.105	**0.0261**

Cont. Forest	0.4322	0.1893	2.283	0.2805
Fragment	-1.1431	0.3194	-3.579	**0.0076**
Edge	0.3347	0.3462	0.967	0.9755
Matrix	0.1672	0.3062	0.546	0.9993

Table S6. Summary results of model averaging of the best-fit GLMMs (Akaike differences < 2 from the best model) investigating the relationship between local and landscape-scale attributes on abundance of eight species between the wet and dry seasons and for five focal scales across the BDFFP, Central Amazon, Brazil. Predictor abbreviations: PFC - primary forest cover; SFC1 - initial secondary forest cover (≤ 5 years); SFC2 - intermediate secondary forest cover (6-15 years); SFC3 - advanced secondary forest cover (≥ 16 years); ED - edge density; PD - patch density; MNND - mean nearest neighbour distance; MSI - mean shape index.

Artibeus obscurus				**Local-scale**	**Compositional Predictors**				**Configurational Predictors**			
Season	**Spatial Scale (m)**	**Explanatory Variables**	**Intercept**	**Vegetation structure**	**PFC**	**SFC1**	**SFC2**	**SFC3**	**PD**	**ED**	**MNND**	**MSI**
Dry Season	**250**	**Estimate (±SE)**	-6.16(0.69)	-0.85(0.33)		0.93(0.41)	-0.56(0.6)	0.61(0.48)	0.15(0.61)	0.32(0.56)	-1.4(0.5)	2.11(0.51)
		95% Confidence interval	-7.51 ; -4.81	-1.5 ; -0.21		0.13 ; 1.74	-1.73 ; 0.61	-0.34 ; 1.56	-1.04 ; 1.34	-0.77 ; 1.41	-2.37 ; -0.42	1.11 ; 3.12
		Hierarchical Partitioning (%)		10.562		44.296	10.231	3.588	10.052	4.766	6.279	10.225
	500	**Estimate (±SE)**	-6.17(0.71)	-0.57(0.34)	-0.73(0.44)	0.52(0.5)		0.78(0.44)				
		95% Confidence interval	-7.57 ; -4.78	-1.24 ; 0.09	-1.6 ; 0.14	-0.46 ; 1.51		-0.08 ; 1.64				
		Hierarchical Partitioning (%)		17.311	25.996	21.344		35.35				
	750	**Estimate (±SE)**	-6.09(0.66)	-0.57(0.34)	-0.79(0.46)			0.93(0.43)				
		95% Confidence interval	-7.38 ; -4.79	-1.24 ; 0.09	-1.69 ; 0.12			0.09 ; 1.77				
		Hierarchical Partitioning (%)		9.623	31.802			58.575				

	1000	Estimate (±SE)	-6.13(0.66)	-0.57(0.34)	-0.73(0.47)	-0.62(0.48)	-0.53(0.35)	1.04(0.41)	-0.83(0.54)			
		95% Confidence interval	-7.42 ; -4.84	-1.24 ; 0.09	-1.66 ; 0.2	-1.55 ; 0.32	-1.22 ; 0.17	0.23 ; 1.85	-1.89 ; 0.23			
		Hierarchical Partitioning (%)		7.743	20.670	2.71	22.159	28.368	18.35			
	1500	Estimate (±SE)	-6.01(0.39)			-0.59(0.54)	-0.79(0.42)	1.26(0.32)				
		95% Confidence interval	-6.77 ; -5.26			-1.64 ; 0.47	-1.6 ; 0.03	0.63 ; 1.89				
		Hierarchical Partitioning (%)				7.195	37.245	55.56				
Wet Season	250	Estimate (±SE)	-6.23(0.32)	0.49 (0.27)	0.41(0.21)	-0.46(0.29)	-0.53(0.27)	-0.32(0.22)				
		95% Confidence interval	-6.85 ; -5.61	-0.03 ; 1.02	-0.01 ; 0.83	-1.02 ; 0.1	-1.06 ; 0.01	-0.75 ; 0.1				
		Hierarchical Partitioning (%)		23.838	26.97	12.109	19.031	18.051				
	500	Estimate (±SE)	-6.23(0.33)	0.49(0.27)	0.37(0.22)			-0.38(0.22)	-0.71(0.36)			
		95% Confidence interval	-6.87 ; -5.59	-0.03 ; 1.02	-0.06 ; 0.79			-0.81 ; 0.05	-1.4 ; -0.01			
		Hierarchical Partitioning (%)		32.592	19.802			23.856	23.751			
	750	Estimate (±SE)	-6.24(0.32)	0.49(0.27)	0.29(0.22)			-0.3(0.23)			-0.33(0.23)	
		95% Confidence interval	-6.87 ; -5.6	-0.03 ; 1.02	-0.14 ; 0.73			-0.74 ; 0.15			-0.78 ; 0.13	
		Hierarchical Partitioning (%)		48.007	14.45			15.278			22.265	

	1000	**Estimate (±SE)**	-6.25(0.32)	0.49(0.27)							-0.32(0.23)	
		95% Confidence interval	-6.88 ; -5.62	-0.03 ; 1.02							-0.77 ; 0.13	
		Hierarchical Partitioning (%)		66.334							33.666	
	1500	**Estimate (±SE)**	-6.25(0.33)	0.49(0.27)			-0.46(0.26)				-0.34(0.22)	
		95% Confidence interval	-6.88 ; -5.61	-0.03 ; 1.02			-0.96 ; 0.05				-0.77 ; 0.1	
		Hierarchical Partitioning (%)		42.998			31.918				25.084	
Carollia brevicauda				**Local-scale**	**Compositional Predictors**				**Configurational Predictors**			
Season	**Spatial Scale (m)**	**Explanatory Variables**	**Intercept**	**Vegetation structure**	**FC**	**SF 1**	**SF 2**	**SF 3**	**PD**	**ED**	**MNND**	**MSI**
Dry Season	**250**	**Estimate (±SE)**	-5.86(0.44)	-0.67(0.27)	-0.7(0.28)			0.64(0.27)	-0.11(0.27)	0.68(0.34)	-0.27(0.35)	0.02(0.32)
		95% Confidence interval	-6.73 ; -4.99	-1.19 ; -0.14	-1.24 ; -0.16			0.11 ; 1.16	-0.65 ; 0.42	0.01 ; 1.36	-0.97 ; 0.42	-0.6 ; 0.65
		Hierarchical Partitioning (%)		1.557	12.250			5.667	8.809	48.671	9.881	13.165
	500	**Estimate (±SE)**	-5.82(0.41)	-0.56(0.23)	-0.69(0.29)			0.64(0.28)				
		95% Confidence interval	-6.63 ; -5.01	-1.01 ; -0.11	-1.27 ; -0.11			0.09 ; 1.2				
		Hierarchical Partitioning (%)		6.659	30.84			62.502				
	750	**Estimate (±SE)**	-5.82(0.4)	-0.56(0.23)	-0.66(0.33)			0.66(0.27)				
		95% Confidence interval	-6.62 ; -5.03	-1.01 ; -0.11	-1.3 ; -0.02			0.13 ; 1.19				

		Hierarchical Partitioning (%)		3.268	33.216			63.516				
	1000	**Estimate (±SE)**	-5.84(0.36)	-0.5(0.26)	-0.55(0.21)			0.6(0.26)	-0.78(0.53)	-0.42(0.48)	0.04(0.42)	0.21(0.38)
		95% Confidence interval	-6.54 ; -5.15	-1.01 ; 0	-0.96 ; -0.14			0.09 ; 1.11	-1.82 ; 0.25	-1.35 ; 0.51	-0.79 ; 0.87	-0.54 ; 0.96
		Hierarchical Partitioning (%)		2.176	16.35			24.607	22.987	20.068	10.773	3.038
	1500	**Estimate (±SE)**	-5.93(0.27)	-0.38(0.22)					-0.2(0.46)	-0.75(0.32)	0.98(0.24)	0.44(0.23)
		95% Confidence interval	-6.45 ; -5.4	-0.8 ; 0.05					-1.09 ; 0.69	-1.37 ; -0.13	0.51 ; 1.45	-0.01 ; 0.9
		Hierarchical Partitioning (%)		3.73					14.935	33.634	29.752	17.949
Wet Season	**250**	**Estimate (±SE)**	-5.01(0.22)	-0.44(0.16)	-0.47(0.2)			0.48(0.18)				
		95% Confidence interval	-5.44 ; -4.57	-0.75 ; -0.12	-0.87 ; -0.07			0.14 ; 0.83				
		Hierarchical Partitioning (%)		20.279	30.319			49.403				
	500	**Estimate (±SE)**	-5.01(0.23)	-0.44(0.16)	-0.51(0.24)			0.49(0.22)				0.38(0.18)
		95% Confidence interval	-5.47 ; -4.55	-0.75 ; -0.12	-0.98 ; -0.03			0.06 ; 0.91				0.02 ; 0.74
		Hierarchical Partitioning (%)		27.6	14.077			20.125				38.198
	750	**Estimate (±SE)**	-4.95(0.29)	-0.38(0.17)	-0.78(0.28)				-1.27(0.38)	0.67(0.3)	0.2(0.19)	-0.38(0.24)
		95% Confidence interval	-5.53 ; -4.37	-0.72 ; -0.05	-1.34 ; -0.23				-2.02 ; -0.52	0.08 ; 1.27	-0.17 ; 0.56	-0.84 ; 0.09
		Hierarchical Partitioning (%)		20.099	6.009				34.724	16.163	12.771	10.235

	1000	**Estimate (±SE)**	-5(0.23)	-0.44(0.16)								
		95% Confidence interval	-5.44 ; -4.56	-0.75 ; -0.12								
		Hierarchical Partitioning (%)		100								
	1500	**Estimate (±SE)**	-4.96(0.28)	-0.44(0.16)							0.67(0.26)	
		95% Confidence interval	-5.51 ; -4.41	-0.75 ; -0.12							0.16 ; 1.18	
		Hierarchical Partitioning (%)		63.684							36.316	
Carollia perspicillata				**Local-scale**	**Compositional Predictors**				**Configurational Predictors**			
Season	**Spatial Scale (m)**	**Explanatory Variables**	**Intercept**	**Vegetation structure**	**FC**	**SF 1**	**SF 2**	**SF 3**	**PD**	**ED**	**MNND**	**MSI**
Dry Season	**250**	**Estimate (±SE)**	-2.27(0.17)	-0.27(0.13)	-0.38(0.19)				0.05(0.15)	0.45(0.17)	0.05(0.2)	-0.21(0.21)
		95% Confidence interval	-2.61 ; -1.93	-0.52 ; -0.02	-0.76 ; 0				-0.24 ; 0.34	0.11 ; 0.79	-0.33 ; 0.44	-0.62 ; 0.21
		Hierarchical Partitioning (%)		8.224	6.146				10.958	65.287	3.027	6.358
	500	**Estimate (±SE)**	-2.24(0.14)	-0.19(0.11)	-0.69(0.21)			0.58(0.11)	-0.28(0.17)	0.15(0.12)	-0.42(0.17)	-0.1(0.12)
		95% Confidence interval	-2.51 ; -1.97	-0.41 ; 0.03	-1.1 ; -0.29			0.36 ; 0.79	-0.61 ; 0.05	-0.08 ; 0.38	-0.75 ; -0.09	-0.34 ; 0.14
		Hierarchical Partitioning (%)		15.828	29.006			16.875	7.144	2.578	23.116	5.453

	750	**Estimate (±SE)**	-2.23(0.13)		-0.6(0.13)			0.62(0.11)				
		95% Confidence interval	-2.49 ; -1.98		-0.86 ; -0.35			0.4 ; 0.84				
		Hierarchical Partitioning (%)			36.734			63.266				
	1000	**Estimate (±SE)**	-2.25(0.14)	-0.12(0.12)	-0.7(0.16)			0.61(0.12)	-0.46(0.25)	-0.29(0.21)	0.11(0.16)	0.12(0.19)
		95% Confidence interval	-2.52 ; -1.97	-0.34 ; 0.11	-1.02 ; -0.38			0.38 ; 0.84	-0.94 ; 0.02	-0.7 ; 0.11	-0.21 ; 0.42	-0.25 ; 0.5
		Hierarchical Partitioning (%)		14.07	25.697			33.757	7.392	3.781	11.233	4.071
	1500	**Estimate (±SE)**	-2.28(0.26)	-0.08(0.09)	-0.88(0.23)				-0.92(0.28)	-0.25(0.2)	0.34(0.15)	-0.01(0.13)
		95% Confidence interval	-2.78 ; -1.78	-0.26 ; 0.1	-1.32 ; -0.44				-1.48 ; -0.36	-0.65 ; 0.15	0.05 ; 0.64	-0.25 ; 0.24
		Hierarchical Partitioning (%)		21.504	40.614				12.549	6.566	13.276	5.491
Wet Season	**250**	**Estimate (±SE)**	-2.47(0.12)	-0.38(0.11)					0.03(0.16)	0.34(0.15)	0.16(0.15)	-0.03(0.17)
		95% Confidence interval	-2.7 ; -2.24	-0.6 ; -0.17					-0.3 ; 0.35	0.05 ; 0.63	-0.14 ; 0.45	-0.36 ; 0.3
		Hierarchical Partitioning (%)		34.678					16.328	33.769	10.314	4.910
	500	**Estimate (±SE)**	-2.47(0.08)	-0.29(0.1)	-0.55(0.15)				-0.72(0.16)	0.49(0.11)	-0.07(0.16)	-0.38(0.12)
		95% Confidence interval	-2.62 ; -2.32	-0.5 ; -0.09	-0.84 ; -0.27				-1.04 ; -0.4	0.26 ; 0.71	-0.37 ; 0.24	-0.61 ; -0.16
		Hierarchical Partitioning (%)		14.991	38.440				16.231	11.287	10.226	8.824

	750	**Estimate (±SE)**	-2.47(0.08)	-0.33(0.11)	-0.42(0.12)				-0.65(0.18)	0.61(0.16)	-0.21(0.13)	-0.5(0.13)
		95% Confidence interval	-2.63 ; -2.32	-0.54 ; -0.11	-0.66 ; -0.18				-1 ; -0.3	0.3 ; 0.92	-0.47 ; 0.06	-0.76 ; -0.24
		Hierarchical Partitioning (%)		16.4	49.364				8.130	4.530	11.637	9.939
	1000	**Estimate (±SE)**	-2.48(0.14)	-0.33(0.12)	-0.64(0.22)			0.51(0.11)	-0.95(0.3)	0.38(0.22)	-0.31(0.17)	-0.45(0.22)
		95% Confidence interval	-2.76 ; -2.2	-0.56 ;-0.11	-1.07 ;-0.2			0.3 ;0.72	-1.54 ;-0.37	-0.04 ;0.8	-0.64 ;0.02	-0.88 ; -0.01
		Hierarchical Partitioning (%)		12.107	35.860			31.483	8.419	2.690	8.297	1.140
	1500	**Estimate (±SE)**	-2.48(0.1)					0.53(0.11)				
		95% Confidence interval	-2.68 ;-2.27					0.32 ;0.74				
		Hierarchical Partitioning (%)						100				
Rhinophylla pumilio				**Local-scale**	**Compositional Predictors**				**Configurational Predictors**			
Season	**Spatial Scale (m)**	**Explanatory Variables**	**Intercept**	**Vegetation structure**	**FC**	**SF 1**	**SF 2**	**SF 3**	**PD**	**ED**	**MNND**	**MSI**
Dry Season	**250**	**Estimate (±SE)**	-3.67(0.19)			-0.2(0.08)				0.17(0.07)		
		95% Confidence interval	-4.05 ;-3.29			-0.36 ;-0.04				0.02 ;0.31		
		Hierarchical Partitioning (%)				11.131				88.869		
	500	**Estimate (±SE)**	-3.65(0.18)	0.04(0.1)	-0.05(0.11)	-0.03(0.12)	0.09(0.1)	0.05(0.12)	-0.12(0.12)	0.09(0.11)	0(0.11)	-0.03(0.09)
		95% Confidence interval	-4 ;-3.31	-0.15 ;0.23	-0.27 ;0.16	-0.26 ;0.19	-0.11 ;0.29	-0.18 ;0.29	-0.36 ;0.11	-0.12 ;0.3	-0.21 ;0.2	-0.2 ; 0.14

		Hierarchical Partitioning (%)		23.231	7.261	3.435	5.985	5.977	37.142	7.465	2.406	7.097
	750	**Estimate (±SE)**	-3.61(0.12)	0.06(0.09)	-0.38(0.08)				-0.63(0.34)	0.33(0.12)	0.05(0.12)	-0.32(0.1)
		95% Confidence interval	-3.85 ;-3.37	-0.12 ;0.24	-0.54 ;-0.22				-1.3 ;0.04	0.1 ;0.57	-0.2 ;0.29	-0.51 ; -0.12
		Hierarchical Partitioning (%)		35.171	19.345				14.906	4.305	20.321	5.952
	1000	**Estimate (±SE)**	-3.64(0.17)	0.04(0.1)	-0.15(0.11)	0.11(0.17)	0.05(0.1)	0.17(0.12)	-0.11(0.12)	0.09(0.14)	-0.05(0.11)	0.09(0.09)
		95% Confidence interval	-3.98 ;-3.3	-0.15 ;0.23	-0.37 ;0.07	-0.22 ;0.44	-0.15 ;0.24	-0.06 ;0.39	-0.35 ;0.14	-0.18 ;0.36	-0.26 ;0.16	-0.09 ; 0.27
		Hierarchical Partitioning (%)		26.407	11.833	2.051	5.232	11.688	8.394	2.349	31.088	0.958
	1500	**Estimate (±SE)**	-3.6(0.16)		-0.18(0.11)	0.16(0.12)		0.2(0.11)			0.13(0.11)	
		95% Confidence interval	-3.91 ;-3.29		-0.41 ;0.04	-0.08 ;0.41		-0.03 ;0.42			-0.08 ;0.35	
		Hierarchical Partitioning (%)			24.175	13.543		35.078			27.204	
Wet Season	**250**	**Estimate (±SE)**	-3.62(0.08)	-0.2(0.08)	-0.22(0.08)	-0.14(0.09)	0.07(0.08)	0.23(0.09)				
		95% Confidence interval	-3.77 ;-3.46	-0.36 ;-0.05	-0.38 ;-0.06	-0.31 ;0.03	-0.09 ;0.23	0.07 ;0.4				
		Hierarchical Partitioning (%)		7.984	19.453	30.208	21.624	20.731				
	500	**Estimate (±SE)**	-3.62(0.08)	-0.2(0.08)	-0.22(0.08)		0.22(0.08)			0.21(0.08)		
		95% Confidence interval	-3.78 ;-3.46	-0.36 ;-0.05	-0.38 ;-0.06		0.07 ;0.38			0.05 ;0.37		

		Hierarchical Partitioning (%)		10.383	17.040		35.161			37.415		
	750	**Estimate (±SE)**	-3.62(0.08)		-0.24(0.08)							
		95% Confidence interval	-3.77 ;-3.47		-0.4 ;-0.09							
		Hierarchical Partitioning (%)			100							
	1000	**Estimate (±SE)**	-3.62(0.08)		-0.25(0.08)						0.23(0.08)	
		95% Confidence interval	-3.77 ;-3.47		-0.4 ;-0.1						0.08 ;0.38	
		Hierarchical Partitioning (%)			73.698						26.302	
	1500	**Estimate (±SE)**	-3.62(0.08)		-0.23(0.08)			0.21(0.08)			0.24(0.08)	
		95% Confidence interval	-3.77 ;-3.46		-0.39 ;-0.08			0.06 ;0.37			0.08 ;0.4	
		Hierarchical Partitioning (%)			50.263			31.083			18.655	
Lophostoma silvicolum				**Local-scale**	**Compositional Predictors**				**Configurational Predictors**			
Season	**Spatial Scale (m)**	**Explanatory Variables**	**Intercept**	**Vegetation structure**	**FC**	**SF 1**	**SF 2**	**SF 3**	**PD**	**ED**	**MNND**	**MSI**
Dry Season	**250**	**Estimate (±SE)**	-5.76(0.3)	0.47(0.3)	0.28(0.2)			-0.36(0.22)		0.26(0.25)	-0.31(0.28)	
		95% Confidence interval	-6.35 ;-5.17	-0.12 ;1.07	-0.11 ;0.66			-0.78 ;0.06		-0.23 ;0.76	-0.86 ;0.23	
		Hierarchical Partitioning (%)		39.627	20.982			25.402		1.585	12.404	

	500	**Estimate (±SE)**	-5.96(0.29)						0.14(0.8)	-0.45(0.26)	-1.11(0.37)	0.89(0.27)
		95% Confidence interval	-6.52 ;-5.39						-1.43 ;1.71	-0.97 ;0.06	-1.84 ;-0.39	0.35 ; 1.42
		Hierarchical Partitioning (%)							18.759	11.702	61.324	8.215
	750	**Estimate (±SE)**	-5.95(0.31)						-0.89(0.33)			
		95% Confidence interval	-6.56 ;-5.33						-1.54 ;-0.24			
		Hierarchical Partitioning (%)							100			
	1000	**Estimate (±SE)**	-6.03(0.33)						-1.08(0.36)			
		95% Confidence interval	-6.68 ;-5.38						-1.79 ;-0.37			
		Hierarchical Partitioning (%)							100			
	1500	**Estimate (±SE)**	-5.95(0.3)						-0.85(0.28)			
		95% Confidence interval	-6.53 ;-5.37						-1.4 ;-0.31			
		Hierarchical Partitioning (%)							100			
Wet Season	**250**	**Estimate (±SE)***	-5.63(0.22)	0.35(0.19)	17.47(32.75)	2.72(5.29)	2.08(6.99)	5.31(17.65)				
		95% Confidence interval*	-6.07 ;-5.19	-0.03 ;0.72	-46.71 ;81.65	-7.65 ;13.09	-11.63 ;15.78	-29.28 ;39.9				
		Hierarchical Partitioning (%)		20.908	24.18	12.12	18.134	24.659				

	500	**Estimate (±SE)**	-5.64(0.21)								-0.6(0.17)	
		95% Confidence interval	-6.05 ;-5.24								-0.94 ;-0.27	
		Hierarchical Partitioning (%)									100	
	750	**Estimate (±SE)**	-5.67(0.21)								-0.63(0.18)	
		95% Confidence interval	-6.09 ;-5.26								-0.98 ;-0.29	
		Hierarchical Partitioning (%)									100	
	1000	**Estimate (±SE)**	-5.64(0.21)				-0.55(0.16)		-0.7(0.22)			
		95% Confidence interval	-6.06 ;-5.22				-0.87 ;-0.24		-1.14 ;-0.26			
		Hierarchical Partitioning (%)					62.453		37.547			
	1500	**Estimate (±SE)**	-5.62(0.21)				-0.46(0.17)		-0.58(0.2)	-0.51(0.18)		
		95% Confidence interval	-6.04 ;-5.2				-0.79 ;-0.14		-0.97 ;-0.18	-0.85 ;-0.16		
		Hierarchical Partitioning (%)					33.951		33.360	32.688		
Mimon crenulatum				**Local-scale**	**Compositional Predictors**				**Configurational Predictors**			
Season	**Spatial Scale (m)**	**Explanatory Variables**	**Intercept**	**Vegetation structure**	**FC**	**SF 1**	**SF 2**	**SF 3**	**PD**	**ED**	**MNND**	**MSI**
Dry Season	**250**	**Estimate (±SE)**	-5.95(0.35)			-0.86(0.38)						
		95% Confidence interval	-6.63 ;-5.27			-1.6 ;-0.13						

		Hierarchical Partitioning (%)				100						
	500	**Estimate (±SE)**	-5.95(0.38)		0.44(0.27)	-0.41(0.31)	0.57(0.25)	-0.59(0.32)	-0.55(0.38)		-0.59(0.35)	
		95% Confidence interval	-6.7 ;-5.2		-0.09 ;0.98	-1.01 ;0.19	0.07 ;1.07	-1.22 ;0.03	-1.29 ;0.2		-1.28 ;0.09	
		Hierarchical Partitioning (%)			26.698	7.417	6.56	31.21	5.392		22.722	
	750	**Estimate (±SE)**	-5.93(0.36)		0.43(0.26)			-0.49(0.27)				
		95% Confidence interval	-6.64 ;-5.22		-0.09 ;0.94			-1.02 ;0.05				
		Hierarchical Partitioning (%)			48.661			51.339				
	1000	**Estimate (±SE)**	-5.91(0.36)		0.41(0.26)			-0.47(0.27)				
		95% Confidence interval	-6.61 ;-5.21		-0.1 ;0.91			-0.99 ;0.06				
		Hierarchical Partitioning (%)			48.245			51.755				
	1500	**Estimate (±SE)**	-5.92(0.36)		0.47(0.27)			-0.5(0.27)				
		95% Confidence interval	-6.62 ;-5.22		-0.06 ;0.99			-1.03 ;0.03				
		Hierarchical Partitioning (%)			48.893			51.107				
Wet Season	**250**	**Estimate (±SE)**	-5.87(0.25)			-1.09(0.3)	0.42(0.16)	0.36(0.19)				
		95% Confidence interval	-6.35 ;-5.39			-1.69 ;-0.49	0.12 ;0.73	-0.02 ;0.74				
		Hierarchical Partitioning (%)				50.461	42.023	7.516				

	500	**Estimate (±SE)**	-5.75(0.24)				0.62(0.2)					
		95% Confidence interval	-6.22 ;-5.27				0.24 ;1					
		Hierarchical Partitioning (%)					100					
	750	**Estimate (±SE)**	-5.81(0.3)				0.66(0.22)		-1.68(0.58)	1.27(0.48)	0.72(0.23)	-0.61(0.35)
		95% Confidence interval	-6.39 ;-5.24				0.24 ;1.09		-2.81 ;-0.55	0.34 ;2.21	0.27 ;1.18	-1.29 ; 0.07
		Hierarchical Partitioning (%)					41.232		24.726	11.239	17.984	4.818
	1000	**Estimate (±SE)**	-5.8(0.25)				0.72(0.23)					
		95% Confidence interval	-6.29 ;-5.31				0.26 ;1.17					
		Hierarchical Partitioning (%)					100					
	1500	**Estimate (±SE)**	-5.78(0.3)		1990.95(779.51)	158.14(144.68)	107.85(152.07)	1788.98(700.55)		0.42(0.33)	0.49(0.27)	
		95% Confidence interval	-6.36 ;-5.2		463.14 ;3518.77	-125.43 ;441.71	-190.21 ;405.91	415.94 ;3162.03		-0.23 ;1.06	-0.05 ;1.03	
		Hierarchical Partitioning (%)			17.994	11.253	17.47	21.297		4.632	27.354	
Trachops cirrhosus				**Local-scale**	**Compositional Predictors**				**Configurational Predictors**			
Season	**Spatial Scale (m)**	**Explanatory Variables**	**Intercept**	**Vegetation structure**	**FC**	**SF 1**	**SF 2**	**SF 3**	**PD**	**ED**	**MNND**	**MSI**
Dry Season	**250**	**Estimate (±SE)**	-6.05(0.41)	0.54(0.37)		-0.78(0.39)					-0.36(0.32)	
		95% Confidence interval	-6.85 ;-5.25	-0.18 ;1.26		-1.54 ;-0.02					-0.99 ;0.27	

		Hierarchical Partitioning (%)		57.573		16.885					25.542	
	500	**Estimate (±SE)**	-5.87(0.49)	0.54(0.37)				-0.35(0.38)		0.56(0.31)	-0.36(0.33)	0.35(0.25)
		95% Confidence interval	-6.83 ;-4.91	-0.18 ;1.26				-1.09 ;0.38		-0.05 ;1.17	-1 ;0.28	-0.14 ; 0.84
		Hierarchical Partitioning (%)		36.268				24.558		10.102	25.684	3.389
	750	**Estimate (±SE)**	-5.72(0.38)									0.62(0.15)
		95% Confidence interval	-6.47 ;-4.97									0.33 ; 0.91
		Hierarchical Partitioning (%)										100
	1000	**Estimate (±SE)**	-5.97(0.41)	0.54(0.37)	0.53(0.25)			-0.6(0.26)				0.46(0.23)
		95% Confidence interval	-6.77 ;-5.18	-0.18 ;1.26	0.04 ;1.01			-1.1 ;-0.09				0.01 ; 0.9
		Hierarchical Partitioning (%)		34.728	27.018			23.627				14.627
	1500	**Estimate (±SE)**	-5.93(0.42)		0.61(0.25)			-0.61(0.26)				0.56(0.22)
		95% Confidence interval	-6.75 ;-5.11		0.12 ;1.09			-1.11 ;-0.11				0.13 ; 1
		Hierarchical Partitioning (%)			38.628			30.812				30.56
Wet Season	**250**	**Estimate (±SE)**	-5.35 (0.28)		0.47(0.19)			-0.51(0.19)				
		95% Confidence interval	-5.89 ;-4.81		0.1 ;0.84			-0.88 ;-0.13				
		Hierarchical Partitioning (%)			49.239			50.761				

	500	**Estimate (±SE)**	-5.35(0.24)								-0.65(0.19)	
		95% Confidence interval	-5.83 ;-4.87								-1.02 ;-0.29	
		Hierarchical Partitioning (%)									100	
	750	**Estimate (±SE)**	-5.35(0.25)								-0.65(0.19)	
		95% Confidence interval	-5.84 ;-4.86								-1.02 ;-0.28	
		Hierarchical Partitioning (%)									100	
	1000	**Estimate (±SE)**	-5.37(0.25)								-0.66(0.18)	
		95% Confidence interval	-5.86 ;-4.88								-1.02 ;-0.31	
		Hierarchical Partitioning (%)									100	
	1500	**Estimate (±SE)**	-5.28(0.19)							-0.7(0.16)		
		95% Confidence interval	-5.65 ;-4.91							-1.01 ;-0.39		
		Hierarchical Partitioning (%)								100		
Pteronotus parnellii				**Local-scale**	**Compositional Predictors**				**Configurational Predictors**			
Season	**Spatial Scale (m)**	**Explanatory Variables**	**Intercept**	**Vegetation structure**	**FC**	**SF 1**	**SF 2**	**SF 3**	**PD**	**ED**	**MNND**	**MSI**
Dry Season	**250**	**Estimate (±SE)**	-4.56(0.24)			-0.45(0.15)						
		95% Confidence interval	-5.02 ;-4.09			-0.74 ;-0.16						

		Hierarchical Partitioning (%)				100						
	500	**Estimate (±SE)**	-4.59(0.25)		0.37(0.13)	-0.46(0.16)		-0.36(0.13)			-0.37(0.15)	
		95% Confidence interval	-5.09 ;-4.09		0.11 ;0.64	-0.78 ;-0.13		-0.61 ;-0.11			-0.66 ;-0.08	
		Hierarchical Partitioning (%)			31.177	13.027		27.668			28.128	
	750	**Estimate (±SE)**	-4.49(0.19)			-0.47(0.18)						
		95% Confidence interval	-4.86 ;-4.13			-0.83 ;-0.12						
		Hierarchical Partitioning (%)				100						
	1000	**Estimate (±SE)**	-4.49(0.2)	0.19(0.15)		-0.46(0.22)	0.3(0.14)	-0.09(0.15)			-0.21(0.14)	
		95% Confidence interval	-4.89 ;-4.09	-0.09 ;0.48		-0.88 ;-0.03	0.04 ;0.57	-0.37 ;0.2			-0.48 ;0.06	
		Hierarchical Partitioning (%)		26.385		14.205	11.224	9.604			38.582	
	1500	**Estimate (±SE)**	-4.6(0.26)								-0.31(0.14)	
		95% Confidence interval	-5.11 ;-4.09								-0.58 ;-0.03	
		Hierarchical Partitioning (%)									100	
Wet Season	**250**	**Estimate (±SE)**	-4.5(0.14)						0.55(0.21)	-0.81(0.2)	-0.28(0.15)	0.41(0.19)
		95% Confidence interval	-4.77 ;-4.23						0.14 ;0.96	-1.21 ;-0.41	-0.58 ;0.02	0.04 ; 0.77
		Hierarchical Partitioning (%)							11.062	49.35	16.765	22.823

	500	**Estimate (±SE)**	-4.5(0.15)		0.4(0.13)			-0.4(0.13)					
		95% Confidence interval	-4.79 ;-4.21		0.15 ;0.66			-0.66 ;-0.14					
		Hierarchical Partitioning (%)			53.247			46.753					
	750	**Estimate (±SE)**	-4.5(0.15)		0.4(0.13)			-0.4(0.13)					
		95% Confidence interval	-4.79 ;-4.21		0.15 ;0.65			-0.65 ;-0.14					
		Hierarchical Partitioning (%)			54.196			45.804					
	1000	**Estimate (±SE)**	-4.49(0.15)		0.38(0.13)			-0.38(0.13)					
		95% Confidence interval	-4.78 ;-4.21		0.13 ;0.64			-0.64 ;-0.12					
		Hierarchical Partitioning (%)			54.699			45.301					
	1500	**Estimate (±SE)**	-4.49(0.15)		0.38(0.13)			-0.37(0.13)			-0.35(0.13)		
		95% Confidence interval	-4.78 ;-4.2		0.12 ;0.63			-0.62 ;-0.11			-0.61 ;-0.1		
		Hierarchical Partitioning (%)			33.731			28.076			38.193		

Table S7. Best-fit models ($\Delta AIC_c \leq 2$) investigating the relationship between local and landscape-scale attributes and abundance of eight species for the wet and dry seasons and for five focal scales across the BDFFP, Central Amazon, Brazil. For each model, the number of estimated parameters (*K*), sample-size adjusted Akaike's information criterion (AIC_c), Akaike differences (Δ_i), Akaike weights (w_i), cumulative Akaike weight (Cum_W) and log-likelihood (log(L)) are presented. Predictor abbreviations: LVS – local vegetation structure; PFC – primary forest cover; SFC1 – initial secondary forest cover; SFC2 – intermediate secondary forest cover; SFC3 – advanced secondary forest cover; ED – edge density; PD – patch density; MNND – mean nearest neighbour distance; MSI – mean shape index;

Artibeus obscurus								
Season	**Spatial Scale (m)**	**Model structure**	***K***	**AIC_c**	**Δ_i**	**w_i**	**Cum**	**log(L)**
Dry Season	**250**	SFC1	4	137.20	0	0.28	0.28	-64.01
		LVS+SFC1+SFC2+SFC3+ED+PD+MNND+MSI	11	138.98	1.78	0.12	0.40	-53.60
		ED	4	139.01	1.81	0.11	0.51	-64.92
		PD	4	139.09	1.89	0.11	0.62	-64.96
	500	SFC3	4	139.14	0	0.20	0.20	-64.98
		LVS	4	139.39	0.25	0.17	0.37	-65.11
		PFC	4	139.41	0.27	0.17	0.55	-65.12
		SFC1	4	140.91	1.76	0.08	0.63	-65.87
	750	SFC3	4	138.10	0	0.30	0.30	-64.46

		PFC	4	139.32	1.22	0.16	0.46	-65.07
		LVS	4	139.39	1.29	0.16	0.62	-65.11
	1000	SFC3	4	138.19	0	0.22	0.22	-64.51
		SFC1+SFC2+SFC3	6	138.84	0.65	0.16	0.38	-62.11
		LVS	4	139.39	1.20	0.12	0.50	-65.11
		PD	4	139.53	1.34	0.11	0.61	-65.17
		PFC	4	139.80	1.61	0.10	0.71	-65.31
	1500	SFC1+SFC2+SFC3	6	132.84	0	0.52	0.52	-59.11
Wet Season	**250**	SFC2	4	100.74	0	0.24	0.24	-45.78
		LVS	4	101.21	0.46	0.19	0.43	-46.02
		PFC	4	101.31	0.57	0.18	0.61	-46.07
		SFC1	4	102.06	1.32	0.12	0.73	-46.44
		SFC3	4	102.73	1.99	0.09	0.82	-46.78
	500	PD	4	100.12	0	0.29	0.29	-45.47
		LVS	4	101.21	1.09	0.17	0.46	-46.02

		SFC3	4	101.87	1.75	0.12	0.59	-46.35
		PFC	4	102.03	1.91	0.11	0.70	-46.43
	750	LVS	4	101.21	0	0.28	0.28	-46.02
		MNND	4	102.86	1.66	0.12	0.40	-46.84
		PFC	4	103.10	1.89	0.11	0.51	-46.96
		SFC3	4	103.17	1.96	0.10	0.61	-47
	1000	LVS	4	101.21	0	0.33	0.33	-46.02
		MNND	4	102.92	1.71	0.14	0.47	-46.87
	1500	SFC2	4	101.10	0	0.25	0.25	-45.96
		LVS	4	101.21	0.10	0.23	0.48	-46.02
		MNND	4	102.55	1.45	0.12	0.60	-46.69
Carollia brevicauda								
Season	**Spatial Scale (m)**	**Model structure**	***K***	**AIC_c**	**Δ_i**	**w_i**	**Cum**	**log(L)**
Dry Season	**250**	PFC	4	99.32	0	0.24	0.24	-45.07
		LVS	4	100.15	0.83	0.16	0.40	-45.49

		SFC3	4	100.60	1.27	0.13	0.53	-45.71
		LVS+ED+PD+MNND+MSI	8	100.85	1.53	0.11	0.65	-40.03
		ED	4	101.19	1.87	0.10	0.74	-46.01
	500	LVS	4	100.15	0	0.31	0.31	-45.49
		PFC	4	100.57	0.42	0.25	0.56	-45.70
		SFC3	4	101.04	0.89	0.20	0.76	-45.93
	750	LVS	4	100.15	0	0.32	0.32	-45.49
		SFC3	4	100.80	0.65	0.23	0.55	-45.81
		PFC	4	101.71	1.55	0.15	0.70	-46.27
	1000	LVS	4	100.15	0	0.24	0.24	-45.49
		LVS+PFC+ED+PD+MNND+MSI	9	100.53	0.38	0.20	0.44	-38.16
		SFC3	4	101.48	1.33	0.12	0.56	-46.15
	1500	ED+PD+MNND+MSI	7	90.59	0	0.47	0.47	-36.49
		LVS+ED+PD+MNND+MSI	8	90.79	0.20	0.42	0.89	-35
Wet Season	**250**	SFC3	4	165.50	0	0.39	0.39	-78.16

		LVS	4	166.47	0.96	0.24	0.63	-78.65
		PFC	4	167.24	1.74	0.16	0.80	-79.03
	500	LVS	4	166.47	0	0.23	0.23	-78.65
		SFC3	4	166.96	0.49	0.18	0.40	-78.89
		PFC	4	167.61	1.14	0.13	0.53	-79.22
		MSI	4	168.22	1.76	0.09	0.63	-79.52
	750	LVS+PFC+ED+PD+MNND+MSI	9	165.51	0	0.32	0.32	-70.65
		LVS	4	166.47	0.96	0.20	0.51	-78.65
		LVS+ED+PD+MNND+MSI	8	167.28	1.78	0.13	0.64	-73.24
	1000	LVS	4	166.47	0	0.50	0.50	-78.65
	1500	MNND	4	165.35	0	0.46	0.46	-78.09
		LVS	4	166.47	1.12	0.27	0.73	-78.65
Carollia perspicillata								
Season	**Spatial Scale (m)**	**Model structure**	***K***	**AIC_c**	**Δ_i**	**w_i**	**Cum**	**log(L)**
Dry Season	**250**	LVS+ED+PD+MNND+MSI	8	317.37	0	0.40	0.40	-148.28

		LVS+PFC+ED+PD+MNND+MSI	9	318.51	1.14	0.23	0.63	-147.15
		PFC	4	319.06	1.70	0.17	0.80	-154.94
	500	PFC	4	315.94	0	0.36	0.36	-153.38
		LVS+PFC+ED+PD+MNND+MSI	9	316.69	0.75	0.25	0.62	-146.24
		SFC3	4	317.70	1.75	0.15	0.77	-154.26
	750	SFC3	4	313.29	0	0.56	0.56	-152.06
		PFC	4	315.24	1.95	0.21	0.77	-153.03
	1000	SFC3	4	314.21	0	0.51	0.51	-152.51
		LVS+PFC+ED+PD+MNND+MSI	9	315.91	1.71	0.22	0.72	-145.85
	1500	LVS+PFC+ED+PD+MNND+MSI	9	312.48	0	0.45	0.45	-144.14
Wet Season	**250**	LVS+ED+PD+MNND+MSI	8	335.62	0	0.48	0.48	-157.41
	500	LVS+PFC+ED+PD+MNND+MSI	9	325.26	0	0.89	0.89	-150.53
	750	LVS+PFC+ED+PD+MNND+MSI	9	326.73	0	0.90	0.90	-151.26
	1000	PFC	4	333.67	0	0.38	0.38	-162.25
		SFC3	4	334.06	0.39	0.31	0.70	-162.44

		LVS+PFC+ED+PD+MNND+MSI	9	334.98	1.31	0.20	0.90	-155.39
	1500	SFC3	4	332.67	0	0.52	0.52	-161.75
Rhinophylla pumilio								
Season	**Spatial Scale (m)**	**Model structure**	***K***	**AIC_c**	**Δ_i**	**w_i**	**Cum**	**log(L)**
Dry Season	**250**	SFC1	4	193.29	0	0.32	0.32	-92.06
		ED	4	193.97	0.69	0.23	0.55	-92.40
	500	PD	4	197.37	0	0.14	0.14	-94.10
		SFC2	4	197.67	0.30	0.12	0.26	-94.25
		ED	4	197.69	0.32	0.12	0.38	-94.26
		PFC	4	198.19	0.82	0.09	0.47	-94.51
		SFC3	4	198.21	0.84	0.09	0.56	-94.52
		LVS	4	198.22	0.85	0.09	0.65	-94.52
		MSI	4	198.30	0.93	0.09	0.74	-94.56
		SFC1	4	198.32	0.95	0.09	0.82	-94.57
		MNND	4	198.41	1.04	0.08	0.91	-94.62

	750	LVS+PFC+ED+PD+MNND+MSI	9	195.21	0	0.26	0.26	-85.50
		PD	4	197.11	1.90	0.10	0.35	-93.97
	1000	SFC3	4	196.71	0	0.17	0.17	-93.77
		PFC	4	196.83	0.12	0.16	0.32	-93.83
		MSI	4	197.52	0.81	0.11	0.43	-94.17
		PD	4	197.68	0.97	0.10	0.53	-94.25
		SFC1	4	197.94	1.24	0.09	0.62	-94.38
		ED	4	197.98	1.28	0.09	0.71	-94.40
		MNND	4	198.17	1.46	0.08	0.79	-94.50
		SFC2	4	198.21	1.50	0.08	0.87	-94.52
		LVS	4	198.22	1.51	0.08	0.94	-94.52
	1500	SFC3	4	196.05	0	0.19	0.19	-93.44
		PFC	4	196.23	0.18	0.18	0.37	-93.53
		SFC1	4	196.82	0.76	0.13	0.50	-93.82
			4	197.07	1.02	0.12	0.62	-93.95

		MNND						
Wet Season	**250**	SFC3	4	219.36	0	0.27	0.27	-105.09
		PFC	4	219.93	0.58	0.20	0.47	-105.38
		LVS	4	220.78	1.42	0.13	0.60	-105.80
		SFC1+SFC2+SFC3	6	220.98	1.62	0.12	0.72	-103.18
	500	SFC2	4	219.34	0	0.24	0.24	-105.08
		PFC	4	219.73	0.39	0.20	0.44	-105.28
		ED	4	220.33	1	0.15	0.58	-105.58
		LVS	4	220.78	1.45	0.12	0.70	-105.80
	750	PFC	4	218.15	0	0.42	0.42	-104.49
	1000	PFC	4	217.62	0	0.40	0.40	-104.22
		MNND	4	218.68	1.06	0.23	0.63	-104.75
	1500	MNND	4	218.41	0	0.31	0.31	-104.61
		PFC	4	218.81	0.40	0.25	0.56	-104.82
		SFC3	4	220.23	1.82	0.12	0.69	-105.53

Lophostoma silvicolum								
Season	**Spatial Scale (m)**	**Model structure**	***K***	**AIC_c**	**Δ_i**	**w_i**	**Cum**	**log(L)**
Dry Season	**250**	LVS	4	93.09	0	0.22	0.22	-41.96
		SFC3	4	93.69	0.60	0.16	0.38	-42.26
		MNND	4	94.49	1.39	0.11	0.49	-42.65
		PFC	4	94.62	1.53	0.10	0.59	-42.72
		ED	4	94.82	1.73	0.09	0.69	-42.82
	500	ED+PD+MNND+MSI	7	87.20	0	0.45	0.45	-34.79
		PD	4	88.84	1.64	0.20	0.64	-39.83
	750	PD	4	86.46	0	0.64	0.64	-38.64
	1000	PD	4	82.29	0	0.82	0.82	-36.56
	1500	PD	4	84.55	0	0.68	0.68	-37.69
Wet Season	**250**	SFC1+SFC2+SFC3	6	123.40	0	0.21	0.21	-54.39

		SFC2	4	123.93	0.53	0.16	0.37	-57.38
		SFC3	4	124	0.60	0.15	0.52	-57.41
		PFC	4	124.50	1.10	0.12	0.64	-57.66
		LVS	4	124.80	1.40	0.10	0.75	-57.81
		PFC+SFC1+SFC2+SFC3	7	125.25	1.85	0.08	0.83	-53.82
	500	MNND	4	116.74	0	0.64	0.64	-53.78
	750	MNND	4	115.28	0	0.62	0.62	-53.05
	1000	PD	4	117.35	0	0.43	0.43	-54.09
		SFC2	4	117.45	0.10	0.40	0.83	-54.14
	1500	PD	4	119.69	0	0.40	0.40	-55.26
		ED	4	120.58	0.89	0.26	0.65	-55.70
		SFC2	4	121.10	1.41	0.20	0.85	-55.96
Mimon crenulatum								
Season	**Spatial Scale (m)**	**Model structure**	***K***	**AIC_c**	**Δ_i**	**w_i**	**Cum**	**log(L)**
Dry Season	**250**	SFC1	4	104.57	0	0.51	0.51	-47.70

	500	SFC3	4	107.33	0	0.19	0.19	-49.08
		Only SFC Predictors	6	107.57	0.24	0.17	0.36	-46.47
		MNND	4	107.59	0.26	0.17	0.53	-49.21
		SFC1	4	108.37	1.04	0.11	0.65	-49.60
		PFC	4	108.42	1.09	0.11	0.76	-49.62
		PD	4	109.14	1.81	0.08	0.84	-49.98
	750	SFC3	4	107.77	0	0.29	0.29	-49.30
		PFC	4	108.48	0.71	0.20	0.50	-49.65
	1000	SFC3	4	108.08	0	0.26	0.26	-49.45
		PFC	4	108.80	0.71	0.18	0.44	-49.81
	1500	SFC3	4	107.51	0	0.26	0.26	-49.17
		PFC	4	108.02	0.51	0.20	0.46	-49.42
Wet Season	**250**	SFC1+SFC2+SFC3	6	116.11	0	0.61	0.61	-50.74
	500	SFC2	4	124.06	0	0.56	0.56	-57.44

	750	SFC2	4	123.92	0	0.42	0.42	-57.37
		ED+PD+MNND+MSI	7	124.99	1.07	0.25	0.67	-53.69
	1000	SFC2	4	123.62	0	0.58	0.58	-57.22
	1500	SFC2	4	129.33	0	0.22	0.22	-60.08
		MNND	4	129.99	0.66	0.16	0.38	-60.40
		PFC+SFC1+SFC2+SFC3	7	130.28	0.95	0.14	0.52	-56.33
		ED	4	130.57	1.24	0.12	0.64	-60.70
		SFC1	4	131.31	1.98	0.08	0.72	-61.07
Trachops cirrhosus								
Season	**Spatial Scale (m)**	**Model structure**	***K***	**AIC_c**	**Δ_i**	**w_i**	**Cum**	**log(L)**
Dry Season	**250**	SFC1	4	101.15	0	0.28	0.28	-45.99
		LVS	4	101.94	0.79	0.19	0.48	-46.38
		MNND	4	103.13	1.98	0.11	0.58	-46.98
	500	ED	4	101.68	0	0.21	0.21	-46.25
		LVS	4	101.94	0.25	0.18	0.39	-46.38

		MSI	4	102.55	0.87	0.13	0.52	-46.69
		MNND	4	103.30	1.62	0.09	0.62	-47.06
		SFC3	4	103.62	1.94	0.08	0.69	-47.22
	750	MSI	4	94.89	0	0.71	0.71	-42.86
	1000	SFC3	4	100.75	0	0.22	0.22	-45.79
		MSI	4	100.94	0.19	0.20	0.42	-45.88
		PFC	4	101.60	0.86	0.14	0.57	-46.21
		LVS	4	101.94	1.19	0.12	0.69	-46.38
	1500	MSI	4	98.84	0	0.34	0.34	-44.83
		PFC	4	100.02	1.17	0.19	0.52	-45.42
		SFC3	4	100.28	1.44	0.16	0.69	-45.55
Wet Season	**250**	SFC3	4	145.85	0	0.39	0.39	-68.34
		PFC	4	146.67	0.82	0.26	0.66	-68.75
	500	MNND	4	141.63	0	0.70	0.70	-66.23
	750	MNND	4	141.45	0	0.73	0.73	-66.14

	1000	MNND	4	139.86	0	0.79	0.79	-65.34
	1500	ED	4	139.89	0	0.68	0.68	-65.36
Pteronotus parnellii								
Season	**Spatial Scale (m)**	**Model structure**	***K***	**AIC_c**	**Δ_i**	**w_i**	**Cum**	**log(L)**
Dry Season	**250**	SFC1	4	145.71	0	0.47	0.47	-68.26
	500	PFC	4	147.59	0	0.27	0.27	-69.21
		SFC3	4	147.68	0.09	0.26	0.53	-69.25
		SFC1	4	148.03	0.44	0.22	0.75	-69.43
		MNND	4	149.25	1.66	0.12	0.87	-70.04
	750	SFC1	4	148.91	0	0.46	0.46	-69.87
	1000	SFC1	4	151.50	0	0.22	0.22	-71.16
		SFC1+SFC2+SFC3	6	152.22	0.72	0.15	0.37	-68.80
		MNND	4	152.85	1.34	0.11	0.48	-71.83
		LVS	4	153.42	1.92	0.08	0.56	-72.12
	1500	MNND	4	150.74	0	0.44	0.44	-70.78

Wet Season	**250**	ED+PD+MNND+MSI	7	192.85	0	0.49	0.49	-87.62
	500	PFC	4	192.95	0	0.38	0.38	-91.89
		SFC3	4	193.54	0.59	0.28	0.66	-92.18
	750	PFC	4	192.89	0	0.44	0.44	-91.86
		SFC3	4	193.51	0.62	0.32	0.76	-92.17
	1000	PFC	4	193.69	0	0.44	0.44	-92.26
		SFC3	4	194.27	0.58	0.33	0.76	-92.55
	1500	PFC	4	194.13	0	0.31	0.31	-92.48
		SFC3	4	194.96	0.83	0.21	0.52	-92.89
		MNND	4	195.17	1.04	0.19	0.70	-93

Table S8.Results of the model consistency between dry and wet season for bat-landscape relationships.

Species	Model Consistency (%)
Artibeus obscurus	0
Carollia brevicauda	71.43
Carollia perspicillata	71.43
Rhinophylla pumilio	25
Lophostoma silvicolum	40
Mimon crenulatum	28.57
Trachops cirrhosus	33.33
Pteronotus parnellii	37.50